This manual supports the PLOT 50: Statistics, Volume 1, Product Number 4050A01

PLOT 50

STATISTICS

VOLUME 1

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THE MANUAL

PLOT 50: STATISTICS, VOLUME 1 is a collection of general purpose programs categorized as Distributions, Tabled Values, Tests and Simple Regressions, and One Sample Analysis. The programs have been designed to perform rapid calculations and to provide accurate results in easily usable form. This manual is a guide to the execution of the programs.

Although not required to execute programs described here, the 4050 series manuals listed below provide much valuable information:

TITLE	TEKTRONIX PART NUMBER
4051 Graphic System Operator's Manual	070-1940-00
4051 Graphic System Reference Manual	070-2056-00
Plot 50: Introduction To Programming In BASIC	070-2058-00
Plot 50: Introduction To Graphics Programming In BASIC	070-2059-00

Each program is treated as a separate entity, and information applicable to more than one program is given for each program to which it applies. This repetition eliminates the need for "page-flipping", and any program can be executed if you follow the instructions contained here without referring to other sources.

An introduction, a list of assigned variable names, operating instructions, and examples are provided for each program. The introduction contains a description of the program, input requirements, expected output, hardware requirements, and program limits. Methods used to derive results are explained briefly, and supporting references are listed.

Lists of variables used in each program are provided but are not needed for program execution. In the lists, the word "scratch" is used to define interim working values which are used in program operations but are not displayed as output. The variable lists may be disregarded unless program modification is undertaken.

Program loading and execution are described in the OPERATING INSTRUCTIONS which are brief, explicit, and in logical sequence. Throughout the instructions, messages which are displayed by the system are shown in upper case letters. Upper case is also used to designate specific keys on the keyboard (e.g., RETURN, BREAK, AUTO LOAD, etc.).

USER-DEFINABLE KEYS

There are ten user-definable keys at the upper left corner of the 4051 keyboard. Each key may have a specific value when pressed alone, and another value when pressed with the SHIFT key down. When a program which uses the keys has been read into memory, the values assigned to the keys are associated with designated program functions. Then, if a user-definable key is pressed, with our without the SHIFT key, the corresponding program function is activated.

Overlay templates for the user-definable keys are included with the STATISTICS, VOLUME 1 package, and information concerning their use is part of all applicable program execution instructions.

OPERATING CONSIDERATIONS

During program execution, a question mark flashing on the screen indicates that the program is waiting for input data values.

When the display screen is full, a flashing "F" appears in the upper left corner. No additional data will be displayed or accepted until the screen is cleared by pressing the PAGE key.

Messages which appear because of error conditions may be avoided by following the operating instructions carefully. An explanation of the messages is contained in the Graphic System Reference manual.

Whenever possible, the programs in STATISTICS, VOLUME 1 avoid rigid syntactical rules, and human error is forgiven or ignored when practical. This flexibility allows minor variation in program execution procedure. Therefore, no claim is made that the methods detailed here are the "only" way. The instructions will lead to effective results however, and they are offered as a sound base for development of individualized techniques.

F-DISTRIBUTION

DESCRIPTION

This program will calculate the significance level (right-tail probability) of a designated F-value. Five digit accuracy will be determined for significance levels between .0001 and .9999 when degrees of freedom are 1000 or less. Accuracy of two digits or more will result when both degrees of freedom are greater than 1000.

A positive F-value and degrees of freedom for the numerator and denominator are required input. Right-tail probability is the output.

HARDWARE REQUIREMENTS

A Tektronix 4050-Series Graphic System is required.

PROGRAM LIMITS

The F-value must be positive.

Degrees of freedom may be any real number greater than 0.01.

METHODS

The density function of the F-distribution with n and d degrees of freedom is:

$$f(n,d,t) = \frac{n^{n/2} d^{d/2} t^{(n-2)/2} (d+nt)^{-1/2(n+d)},}{B(n/2,d/2)}$$

$t > 0$ where $B(n/2,d/2)$ is the complete beta.

The calculated right tail probability is $\int_x^\infty f(n,d,t)\, dt$.

The F-value is transformed to a beta value.

When both degrees of freedom are 1000 or less, a continued fraction is used to evaluate significance levels (References 1, 2). If both are greater than 1000, a normal approximation is used (Reference 3).

F-DISTRIBUTION

REFERENCES

1. Aroian, T. A., "Continued Fractions for the Incomplete Beta Function", *Annals of Mathematical Statistics*, 12 (1941), pp 218–223.

2. Kopitzke, R. W., "Unpublished Notes".

3. Peizer, D. B., Pratt, J. W., "A Normal Approximation for Binomial, F, Beta, and Other Common Related Tail Probabilities, I *"Journal of the American Statistical Association*, 63 (1968), pp.1457–1483.

VARIABLES

VARIABLE	USAGE
A	Denominator degrees of freedom/2
A1	Scratch
A2	Scratch
B	Numerator degrees of freedom/2
B1	Scratch
B2	Scratch
F	Value of F
F1	Numerator degrees of freedom
F2	Denominator degrees of freedom
I	Scratch
Q	Value of beta
T	Scratch
U	Scratch
V1	Scratch
X	Scratch
Y4	Scratch

F-DISTRIBUTION

PROGRAM LOADING

This program may be loaded automatically from the directory, or manually from the keyboard.

AUTOMATIC LOADING FROM THE DIRECTORY

1. Insert the program tape.
2. Press AUTO LOAD. The program directory will be displayed with the message ENTER THE PROGRAM NUMBER YOU WANT.
3. Enter 1; press RETURN.
4. When the I/O light goes out, execute the program.

MANUAL LOADING FROM THE KEYBOARD

1. Insert the program tape.
2. Enter FIND 2; press RETURN.
3. Enter OLD; press RETURN.
4. When the I/O light goes out, execute the program.

PROGRAM EXECUTION

1. NUM.DF, DEN.DF, F is displayed on the screen. Enter the degrees of freedom and the F-value, using commas to separate values. Press RETURN.
2. The significance level is displayed.
3. Other values may be entered by repeating step 1. To exit from the program, press the RETURN key twice.

EXAMPLE

```
                    F DISTRIBUTION

NUM. DF, DEN. DF, F 5,15,2.4
NUM. DF =5 DEN. DF =15  P(F)=2.4) = 0.086607

NUM. DF, DEN. DF, F 150,600,1.2
NUM. DF =150 DEN. DF =600  P(F)=1.2) = 0.87181

NUM. DF, DEN. DF, F 2,2,19
NUM. DF =2 DEN. DF =2  P(F)=19) = 0.05

NUM. DF, DEN. DF, F 50,20,.74
NUM. DF =50 DEN. DF =20  P(F)=0.74) = 0.80739

NUM. DF, DEN. DF, F
```

DISTRIBUTIONS

t-DISTRIBUTION

DESCRIPTION

This program calculates significance levels for a one-tail and two-tail test for the Students t-value. Accuracy of five or more digits will result for significance levels between .0001 and .9999 when degrees of freedom are 1000 or less. For degrees of freedom greater than 1000, accuracy will be at least two digits.

The degrees of freedom and a calculated Students t-value are required input. Input values are displayed with the resultant significance levels.

HARDWARE REQUIREMENTS

A Tektronix 4050-Series Graphic System is required.

PROGRAM LIMITS

Degrees of freedom should be a real number greater than 0.5.

METHODS

The density function for the t-distribution with n degrees of freedom is:

$$f(n,x) = \frac{\Gamma((n+1)/2)}{\sqrt{\Pi n}\,\Gamma(n/2)} \cdot (1+x^2/n)^{-(n+1)/2}$$

where:

$$-\infty < x < \infty \cdot$$

For degrees of freedom n and calculated t-value t, the quantities calculated are given by:

$$\text{Let } r = |t| \cdot$$

The two-tail significance is:

$$1 - \int_{-r}^{r} f(n,x)\,dx \cdot$$

The one-tail significance is:

$$\int_{r}^{\infty} f(n,x)\,dx = \int_{-\infty}^{-r} f(n,x)\,dx \cdot$$

The calculated t-value is transformed to a beta variable.

t-DISTRIBUTION

If degrees of freedom are 1000 or less, a continued fraction is used to evaluate significance levels (References 1 and 2). If degrees of freedom are greater than 1000, a normal approximation is used (Reference 3).

REFERENCES

1. Aroian, T. A., "Continued Fractions for the Incomplete Beta Function", *Annals of Mathematical Statistics*, 12 (1941), pp 218–223.
2. Kopitzke, R. W., "Unpublished Notes".
3. Peizer, D. B., Pratt, J. W., "A Normal Approximation for Binomial, F, Beta, and Other Common Related Tail Probabilities, I" *Journal of the American Statistical Association*, 63 (1968), pp 1457–1483.

VARIABLES

VARIABLE	USAGE
A	Degrees of freedom/2
A1	Scratch
A2	Scratch
B	Degrees of freedom/2
B1	Scratch
B2	Scratch
F	Value of t
F2	Scratch
I	Counter
Q	Value of beta
T	Scratch
U	Scratch
V1	Scratch
X	Scratch
Y4	Scratch

DISTRIBUTIONS

t-DISTRIBUTION

PROGRAM LOADING

This program may be loaded automatically from the directory, or manually from the keyboard.

AUTOMATIC LOADING FROM THE DIRECTORY

1. Insert the program tape.
2. Press AUTO LOAD. The program directory will be displayed with the message ENTER THE PROGRAM NUMBER YOU WANT.
3. Enter 2; press RETURN.
4. When the I/O light goes out, execute the program.

MANUAL LOADING FROM THE KEYBOARD

1. Insert the program tape.
2. Enter FIND 3; press RETURN.
3. Enter OLD; press RETURN.
4. When the I/O light goes out, execute the program.

PROGRAM EXECUTION

1. When DEGREES OF FREEDOM, T is displayed, enter the values (separated by a comma) and press RETURN.
2. One-tail and two-tail significance levels are displayed.
3. Repeat the operation by entering other values, or exit from the program by pressing the BREAK key twice.

EXAMPLE

```
                    T DISTRIBUTION

DEGREES OF FREEDOM ,T 65,1.4
N=65  T=1.4  ONE TAIL=0.083134   TWO TAIL=0.166268

DEGREES OF FREEDOM ,T 5,-1.5
N=5  T=-1.5  ONE TAIL=0.096952   TWO TAIL=0.193904

DEGREES OF FREEDOM ,T 1200,1.96
N=1200  T=1.96  ONE TAIL=0.025113   TWO TAIL=0.050226

DEGREES OF FREEDOM ,T 690,1.7
N=690  T=1.7  ONE TAIL=0.044791   TWO TAIL=0.089582

DEGREES OF FREEDOM ,T
```

CHI-SQUARE DISTRIBUTION

DESCRIPTION

The chi-square distribution program calculates the right-tail probability (significance level) of the chi-square distribution. For degrees of freedom greater than 0.5 and significance levels between .0001 and .9999, probabilities are calculated with at least five figures of accuracy.

Degrees of freedom and a chi-square value are required input. These values and the significance level are the output.

HARDWARE REQUIREMENTS

A Tektronix 4050-Series Graphic System is required.

PROGRAM LIMITS

Degrees of freedom may be any real number greater than 0.5.

METHODS

The density function of a chi-square random variable with n degrees of freedom is:

$$f(n,t) = \frac{1}{\Gamma(n/2)\, 2^{n/2}}\ e^{-t/2}\ t^{n/2-1}\ .$$

The significance level calculated for a chi-square value x with n degrees of freedom is:

$$P(X \geq x) = \int_x^{\infty} f(n,t)\, dt$$

If the degrees of freedom are 200 or less, two different continued fractions are used (References 1 and 3). If the degrees of freedom are greater than 200, a normal approximation is used (Reference 2).

CHI-SQUARE DISTRIBUTION

REFERENCES

1. Khovanskii, A. N., *The Applications of Continued Fractions and Their Generalizations to Problems in Approximation Theory*, translated by P. Wynn (1963), Groningen: P. Noordhoff.
2. Peizer, D. B., Pratt, J. W., "A Normal Approximation for Binomial, F, Beta, and Other Common Related Tail Probabilities, I", *Journal of the American Statistical Association*, 63 (1968), pp 1416–1456.
3. Wall, H. S., *Analytic Theory of Continued Fractions*, New York: D. Van Nostrand, 1948.

VARIABLES

VARIABLE	USAGE
A	Degrees of freedom/2
A1	Scratch
A2	Scratch
B	Chi-square/2
B1	Scratch
B2	Scratch
C1	Scratch
F	Chi-square
I	Counter
N	Degrees of freedom
P1	Scratch
T	Scratch
X	Scratch

PROGRAM LOADING

This program may be loaded automatically from the directory, or manually from the keyboard.

CHI-SQUARE DISTRIBUTION

AUTOMATIC LOADING FROM THE DIRECTORY

1. Insert the program tape.
2. Press AUTO LOAD. The program directory will be displayed with the message ENTER THE PROGRAM NUMBER YOU WANT.
3. Enter 3; press RETURN.
4. When the I/O light goes out, execute the program.

MANUAL LOADING FROM THE KEYBOARD

1. Insert the program tape.
2. Enter FIND 4; press RETURN.
3. Enter OLD; press RETURN.
4. When the I/O light goes out, execute the program.

PROGRAM EXECUTION

1. When the displayed message is DEGREES OF FREEDOM, CHI-SQUARE, enter the values and press RETURN. The values should be separated by a comma.
2. The input values and the calculated significance level are displayed.
3. Other values may be entered for further calculations, or the BREAK key may be pressed twice to exit from the program.

EXAMPLE

```
                    CHI-SQUARE DISTRIBUTION

DEGREES OF FREEDOM,CHI-SQUARE 50,62.3
N=   50   P(CHI SQUARE >62.3  ) =0.11372

DEGREES OF FREEDOM,CHI-SQUARE 12,49.5
N=   12   P(CHI SQUARE >49.5  ) =1.7099E-6

DEGREES OF FREEDOM,CHI-SQUARE 12,2.3
N=   12   P(CHI SQUARE >2.3  ) =0.99879

DEGREES OF FREEDOM,CHI-SQUARE 1500,1472
N=   1500   P(CHI SQUARE >1472  ) =0.69225

DEGREES OF FREEDOM,CHI-SQUARE
```

GAMMA DISTRIBUTION

DESCRIPTION

This program calculates the right tail probability for a two parameter gamma distribution. When significance levels are between .0001 and .9999, probability statements are calculated with a minimum 3 digit accuracy for all values of a/b greater than .25.

Parameters a and b and the gamma value are required input.

HARDWARE REQUIREMENTS

A Tektronix 4050-Series Graphic System is required.

PROGRAM LIMITS

The ratio of a to b must be greater than .25 ($a/b > 1/4$).

METHODS

The density function of the gamma distribution with parameters a and b is:

$$f(a,b,x) = \frac{1}{\Gamma(a)b^a} x^{a-1} e^{-x/b} , \ 0 < a , 0 < x.$$

The right tail probability calculated is:

$$P(x \geq \alpha) = \int_{\alpha}^{\infty} f(a,b,x) \ dx.$$

If a/b is 100 or less, two different continued fractions are used to evaluate the significance level (References 1 and 3). If a/b is greater than 100, a normal approximation is used (Reference 2).

If a is an even integer and b = 2, the gamma distribution reduces to the chi-square distribution.

GAMMA DISTRIBUTION

REFERENCES

1. Khovanskii, A. N., *The Applications of Continued Fractions and Their Generalizations to Problems in Approximation Theory*, translated by P. Wynn (1963), Groningen: P. Noordhoff.
2. Peizer, D. B., Pratt, J. W., "A Normal Approximation for Binomial, F, Beta, and Other Common Related Tail Probabilities, I", *Journal of the American Statistical Association*, 63 (1968), pp 1416–1456.
3. Wall, H. S., *Analytic Theory of Continued Fractions*, New York: D. Van Nostrand, 1948.

VARIABLES

VARIABLE	USAGE
A	Parameter a
A1	Scratch
A2	Scratch
B	Gamma/2
B1	Scratch
B2	Scratch
C1	Scratch
C2	Parameter b
F	Value of gamma
I	Counter
N	Gamma
P1	Scratch
T	Scratch
X	Scratch

DISTRIBUTIONS

GAMMA DISTRIBUTION

PROGRAM LOADING

This program may be loaded automatically from the directory, or manually from the keyboard.

AUTOMATIC LOADING FROM THE DIRECTORY

1. Insert the program tape.
2. Press AUTO LOAD. The program directory will be displayed with the message ENTER THE PROGRAM NUMBER YOU WANT.
3. Enter 4; press RETURN.
4. When the I/O light goes out, execute the program.

MANUAL LOADING FROM THE KEYBOARD

1. Insert the program tape.
2. Enter FIND 5; press RETURN.
3. Enter OLD; press RETURN.
4. When the I/O light goes out, execute the program.

PROGRAM EXECUTION

1. When the message A, B, GAMMA is displayed, enter the values and press RETURN. Separate value entries with commas.
2. The values just entered and the significance level are displayed.
3. Other values may be entered for further calculations, or the BREAK key may be pressed twice to exit from the program.

EXAMPLE

```
                    GAMMA DISTRIBUTION

A,B,GAMMA 50,2,62.3
A=50  B=2   P(GAMMA> 62.3 )=0.11372

A,B,GAMMA 4.5,1,2.3
A=4.5  B=1   P(GAMMA> 2.3 )=0.86769

A,B,GAMMA 12.3,2.6,1.9
A=12.3  B=2.6   P(GAMMA> 1.9 )=0.99836

A,B,GAMMA
```

NORMAL DISTRIBUTION

DESCRIPTION

This program calculates one-tail and two-tail significance levels for a normal distribution.

The x-value is the only required input. One-tail and two-tail significance levels are displayed with the x-value.

HARDWARE REQUIREMENTS

A Tektronix 4050-Series Graphic System is required.

PROGRAM LIMITS

A normal approximation is used with a maximum error of 7.5×10^{-8}. Increased accuracy is available with the High Accuracy Normal program described in this section.

METHODS

The approximation used by this program is equation 26.2.17 of the reference.

REFERENCE

Abramowitz, M. and Stegun, I. A., editors, *Handbook of Mathematical Functions with Formulas, Graphs, and Mathematical Tables*, Washington, D. C: National Bureau of Standards, Applied Mathematics Series No. 55, Government Printing Office.

VARIABLES

VARIABLE	USAGE
A1	Scratch
T	Scratch
X	Normal deviate

PROGRAM LOADING

This program may be loaded automatically from the directory, or manually from the keyboard.

DISTRIBUTIONS

NORMAL DISTRIBUTION

AUTOMATIC LOADING FROM THE DIRECTORY

1. Insert the program tape.
2. Press AUTO LOAD. The program directory will be displayed with the message ENTER THE PROGRAM NUMBER YOU WANT.
3. Enter 5; press RETURN.
4. When the I/O light goes out, execute the program.

MANUAL LOADING FROM THE KEYBOARD

1. Insert the program tape.
2. Enter FIND 6; press RETURN.
3. Enter OLD; press RETURN.
4. When the I/O light goes out, execute the program.

PROGRAM EXECUTION

1. The displayed message is the letter X. Enter the X-value and press RETURN.
2. The X-value and the significance level are displayed.
3. Additional values may be entered, or the BREAK key may be pressed twice to terminate the program.

EXAMPLE

```
                    NORMAL DISTRIBUTION (APPROXIMATE)

X 1.2
X=1.2   ONE TAIL=0.11507   TWO TAIL=0.23014

X -2.1
X=-2.1   ONE TAIL=0.017864   TWO TAIL=0.035728

X 1.98
X=1.98   ONE TAIL=0.023852   TWO TAIL=0.047704

X
```

BETA DISTRIBUTION

DESCRIPTION

This program calculates right tail probability for the beta distribution with parameters a and b. For right tail probabilities between .0001 and .9999, accuracy of 5 digits or more is provided when both parameters are 500 or less. When both parameters are greater then 500, 3 or more digit accuracy is calculated. The a and b parameters and the X-value required as input are returned with the right tail probability as output.

HARDWARE REQUIREMENTS

A Tektronix 4050-Series Graphic System is required.

PROGRAM LIMITS

Both parameters should be 0.1 or greater.

METHODS

The density function of the beta distribution is:

$$g(a,b,x) = \frac{x^{a-1}\,(1-x)^{b-1}}{B(a,b)} \qquad a > 0,\ b > 0,\ \text{and } 0 \leqslant x \leqslant 1$$

where B(a,b) is the complete beta function.

The right tail probability for parameters a and b and value X is:

$$\int_x^1 g(a,b,t)\,dt.$$

When either a or b are 500 or less, a continuous fraction is used to evaluate right tail probability (Reference 1 and 2). When both are greater than 500, a normal approximation is used (Reference 3).

REFERENCES

1. Aroian, T. A., "Continued Fractions for the Incomplete Beta Function", *Annals of Mathematical Statistics*, 12 (1941), pp 218–223.
2. Kopitzke, R. W., "Unpublished Notes".
3. Peizer, D. B., Pratt, J. W., "A Normal Approximation for Binomial, F, Beta, and Other Common, Related Tail Probabilities, I", *Journal of the American Statistical Association*, 63, (1968), pp 1416–1456.

DISTRIBUTIONS

BETA DISTRIBUTION

VARIABLES

VARIABLE	USAGE
A	Parameter A
A1	Scratch
A2	Scratch
B	Parameter B
B1	Scratch
B2	Scratch
I	Scratch
Q	Value of beta
T	Scratch
U	Scratch
V1	Scratch
X	Scratch
Y4	Scratch

PROGRAM LOADING

This program may be loaded automatically from the directory, or manually from the keyboard.

AUTOMATIC LOADING FROM THE DIRECTORY

1. Insert the program tape.
2. Press AUTO LOAD. The program directory will be displayed with the message ENTER THE PROGRAM NUMBER YOU WANT.
3. Enter 6; press RETURN.
4. When the I/O light goes out, execute the program.

MANUAL LOADING FROM THE KEYBOARD

1. Insert the program tape.
2. Enter FIND 7; press RETURN.
3. Enter OLD; press RETURN.
4. When the I/O light goes out, execute the program.

BETA DISTRIBUTION

PROGRAM EXECUTION

1. A, B, X is displayed. Enter the values separated by commas, and press RETURN.
2. The input values and the calculated right-tail probability are displayed.
3. Other values may be entered in the same manner, or the program may be terminated by pressing the BREAK key twice.

EXAMPLE

```
                    BETA DISTRIBUTION

A,B,X 50,50,.5
A=50   B=50   P(X>0.5)=0.5

A,B,X 24,26.35,.8
A=24   B=26.35   P(X>0.8)=2.0606E-7

A,B,X 1.58,4.36,.12
A=1.58   B=4.36   P(X>0.12)=0.78147

A,B,X
```

DISTRIBUTIONS

POINT BINOMIAL DISTRIBUTION

DESCRIPTION

This program calculates the individual terms of the binomial distribution for input parameters N, R, and P. N denotes the number of trials; R, the number of successes; and P, the probability of success.

HARDWARE REQUIREMENTS

A Tektronix 4050-Series Graphic System is required.

PROGRAM LIMITS

P(X = R) must be greater than 10^{-300}.

METHODS

For each set of parameters, the quantity calculated is

$$P(X = R) = \frac{N!}{(N-R)!\,R!} P^{R}(1-P)^{N-R}$$

If N is less than 50, and R is less than 20, exact factorials are calculated. Otherwise, Sterling's approximation is used.

Probabilities are calculated with a relative error less than 10^{-8}.

REFERENCE

Dixon, W. J., Massey, F. J., *Introduction to Statistical Analysis*, New York: McGraw-Hill, 1957.

POINT BINOMIAL DISTRIBUTION

VARIABLES

VARIABLE	USAGE
A1	Scratch
B1	Scratch
N	Number of trials
P	Probability of success
R	Number of successes
X1	Scratch
X2	Scratch

PROGRAM LOADING

This program may be loaded automatically from the directory, or manually from the keyboard.

AUTOMATIC LOADING FROM THE DIRECTORY

1. Insert the program tape.
2. Press AUTO LOAD. The program directory will be displayed with the message ENTER THE PROGRAM NUMBER YOU WANT.
3. Enter 7; press RETURN.
4. When the I/O light goes out, execute the program.

MANUAL LOADING FROM THE KEYBOARD

1. Insert the program tape.
2. Enter FIND 8; press RETURN.
3. Enter OLD; press RETURN.
4. When the I/O light goes out, execute the program.

POINT BINOMIAL DISTRIBUTION

PROGRAM EXECUTION

1. NUMBER OF TRIALS, NUMBER OF SUCCESSES, PROB OF SUCCESS is displayed. Enter the values separated by commas, and press RETURN.
2. Input values and calculated probability are displayed.
3. Repeat the program execution process for other values, or press BREAK twice to exit from the program.

EXAMPLE

```
                    POINT BINOMIAL DISTRIBUTION

NUMBER OF TRIALS,NUMBER OF SUCCESSES,PROB OF SUCCESS 56,23,.2
N=56   P=0.2   P(X=23)=1.684E-4

NUMBER OF TRIALS,NUMBER OF SUCCESSES,PROB OF SUCCESS 10,5,.8
N=10   P=0.8   P(X=5)=0.026424

NUMBER OF TRIALS,NUMBER OF SUCCESSES,PROB OF SUCCESS 24,23,.2
N=24   P=0.2   P(X=23)=1.6106E-15

NUMBER OF TRIALS,NUMBER OF SUCCESSES,PROB OF SUCCESS
```

SINGLE TERM DISTRIBUTION

DESCRIPTION

For the binomial distribution, this program calculates the probabilities for each term between designated lower and upper limits. The accumulative and right tail probabilities are also calculated.

Required input values are the number of trials, lower and upper term limits, and the probability of success.

HARDWARE REQUIREMENTS

A Tektronix 4050-Series Graphic System is required.

PROGRAM LIMITS

For probability of success P, and number of trials N, $(1-P)^N$ must be greater than 10^{-300}.

The number of trials should be 50 or less. For more than 50 trials, the Accumulative Binomial Distribution program should be used.

METHODS

If X has a binomial distribution with parameters shown above, the probabilities calculated are as follows:

$$\text{single term; } P(X = r) = \binom{N}{r} P^r (1-P)^{N-r},$$

$$\text{accumulative; } P(X \leq j) = \sum_{i=0}^{j} P(X = i)$$

$$\text{right tail; } P(X > j) = 1 - P(X \leq j).$$

P(X = 0) is first calculated. Probabilities for X greater than 0 are then calculated using the recursion relation:

$$P(X = j) = \frac{(N-j+1)}{j} \frac{P}{1-P} P(X = j-1) \text{ for } j = 1,2,\ldots,N.$$

DISTRIBUTIONS

SINGLE TERM DISTRIBUTION

REFERENCE

Dixon, W. J., Massey, F. J., *Introduction To Statistical Analysis*, New York: McGraw-Hill, 1957.

VARIABLES

VARIABLE	USAGE
I	Scratch
N	Number of trials
P	Probability of success
P1	Scratch
P2	Scratch
P3	Scratch
P4	Scratch
R	Number of successes

PROGRAM LOADING

This program may be loaded automatically from the directory, or manually from the keyboard.

AUTOMATIC LOADING FROM THE DIRECTORY

1. Insert the program tape.
2. Press AUTO LOAD. The program directory will be displayed with the message ENTER THE PROGRAM NUMBER YOU WANT.
3. Enter 8; press RETURN.
4. When the I/O light goes out, execute the program.

MANUAL LOADING FROM THE KEYBOARD

1. Insert the program tape.
2. Enter FIND 9; press RETURN.
3. Enter OLD; press RETURN.
4. When the I/O light goes out, execute the program.

SINGLE TERM DISTRIBUTION

PROGRAM EXECUTION

1. NUMBER OF TRIALS, LOWER LIM, UPPER LIM, PROB OF SUCCESS appears on the display screen. Enter values for the number of trials, lower limits, upper limits, and probability of success. A comma must separate the values. Press RETURN.
2. Input values and calculated probabilities are displayed.
3. To re-execute this program, type RUN, press RETURN, and enter new data values.

EXAMPLES

Find the probability of success for all possible values for a binomial distribution with 5 trials and .5 probability of success.

```
                SINGLE TERM BINOMIAL
N=5  P=0.5 PROBABILITIES CALCULATED FROM 0 TO 5 SUCCESSES

  N     Y     P(X=Y)      P(X<=Y)     P(X>Y)
  5     0   0.0312500   0.0312500   0.9687500
  5     1   0.1562500   0.1875000   0.8125000
  5     2   0.3125000   0.5000000   0.5000000
  5     3   0.3125000   0.8125000   0.1875000
  5     4   0.1562500   0.9687500   0.0312500
  5     5   0.0312500   1.0000000   0.0000000
```

For a binomial distribution with probability of success .3, find the probability of 10 successes in 25 trials.

```
                SINGLE TERM BINOMIAL
N=25  P=0.3 PROBABILITIES CALCULATED FROM 10 TO 10 SUCCESSES

  N     Y     P(X=Y)      P(X<=Y)     P(X>Y)
 25    10   0.0916360   0.9022000   0.0978000
```

SINGLE TERM DISTRIBUTION

For a binomial distribution with probability of success .2, find the probability of each success between 90 and 110 for 500 trials.

SINGLE TERM BINOMIAL
N=500 P=0.2 PROBABILITIES CALCULATED FROM 90 TO 110 SUCCESSES

N	Y	P(X=Y)	P(X<=Y)	P(X>Y)
500	90	0.0244260	0.1437028	0.8562972
500	91	0.0275129	0.1712156	0.8287844
500	92	0.0305781	0.2017938	0.7982062
500	93	0.0335373	0.2353311	0.7646689
500	94	0.0363024	0.2716334	0.7283666
500	95	0.0387862	0.3104197	0.6895803
500	96	0.0409073	0.3513270	0.6486730
500	97	0.0425942	0.3939212	0.6060788
500	98	0.0437895	0.4377107	0.5622893
500	99	0.0444530	0.4821637	0.5178363
500	100	0.0445641	0.5267278	0.4732722
500	101	0.0441229	0.5708506	0.4291494
500	102	0.0431496	0.6140002	0.3859998
500	103	0.0416833	0.6556835	0.3443165
500	104	0.0397795	0.6954630	0.3045370
500	105	0.0375064	0.7329694	0.2670306
500	106	0.0349411	0.7679105	0.2320895
500	107	0.0321654	0.8000759	0.1999241
500	108	0.0292616	0.8293375	0.1706625
500	109	0.0263086	0.8556461	0.1443539
500	110	0.0233788	0.8790249	0.1209751

ACCUMULATIVE BINOMIAL DISTRIBUTION

DESCRIPTION

This program calculates the accumulative binomial distribution only. The input parameters are the number of trials and successes, and the probability of success. Output is the accumulative probability of successes.

When the number of trials is 500 or less, a continued fraction is used to evaluate the probability (References 1 and 2). Minimum accuracy is five digits. If trials minus successes plus 1 is greater than 500, a normal approximation is used and minimum accuracy is two digits (Reference 3).

HARDWARE REQUIREMENTS

A Tektronix 4050-Series Graphic System is required.

PROGRAM LIMITS

This program is intended primarily for use when the number of trials exceeds 50. The single term binomial distribution program should be used when the number of trials is 50 or less.

METHODS

When N represents the number of trials, R the number of successes, and P the probability of success, the binomial distribution is defined by:

$$P(X = R) = \frac{N!}{(N-R)!\,R!}\, P^R\,(1-P)^{N-R}.$$

The quantity calculated is:

$$\sum_{i=0}^{R} P(X = i) \cdot$$

For the parameters above, $P(X \geq R)$ is a beta with parameters $a = R$ and $b = N-R+1$, evaluated at $X = P$. The methods used are the same as in the beta program.

ACCUMULATIVE BINOMIAL DISTRIBUTION

REFERENCES

1. Aroian, T. A., "Continued Fractions for the Incomplete Beta Function", *Annals of Mathematical Statistics*, 12 (1941), pp. 218–223.
2. Kopitzke, R. W., "Unpublished Notes."
3. Peizer, D. B., Pratt, J. W., "A Normal Approximation for Binomial, F, Beta, and Other Common Related Tail Probabilities, I" *Journal of the American Statistical Association*, 63 (1968), pp. 1457–1483.

VARIABLES

VARIABLE	USAGE
A	R+1
A1	Scratch
A2	Scratch
B	N–R
B1	Scratch
B2	Scratch
I	Counter
N	Number of successes
P	Probability of success
Q	Value of beta
R	Number of trials
T	Scratch
U	Scratch
V1	Scratch
X	Scratch
Y4	Scratch

ACCUMULATIVE BINOMIAL DISTRIBUTION

PROGRAM LOADING

This program may be loaded automatically from the directory, or manually from the keyboard.

AUTOMATIC LOADING FROM THE DIRECTORY

1. Insert the program tape.
2. Press AUTO LOAD. The program directory will be displayed with the message ENTER THE PROGRAM NUMBER YOU WANT.
3. Enter 9; press RETURN.
4. When the I/O light goes out, execute the program.

MANUAL LOADING FROM THE KEYBOARD

1. Insert the program tape.
2. Enter FIND 10; press RETURN.
3. Enter OLD; press RETURN.
4. When the I/O light goes out, execute the program.

PROGRAM EXECUTION

1. NUMBER OF TRIALS, NUMBER OF SUCCESSES, PROB OF SUCCESS is displayed. Enter the respective values separated by commas. Press RETURN.
2. The accumulative probability will be displayed with the input values.
3. Other values may be entered to execute the program again, or an exit may be called by pressing the BREAK key twice.

EXAMPLE

```
                ACCUMULATIVE BINOMIAL DISTRIBUTION

NUMBER OF TRIALS,NUMBER OF SUCCESSES,PROB OF SUCCESS 500,97,.2
N=500 P=0.2 P(X<=97)=0.39392

NUMBER OF TRIALS,NUMBER OF SUCCESSES,PROB OF SUCCESS 100001,50000,.5
N=100001 P=0.5 P(X<=50000)=0.5

NUMBER OF TRIALS,NUMBER OF SUCCESSES,PROB OF SUCCESS 50000,2500,.9
N=50000 P=0.9 P(X<=2500)=0

NUMBER OF TRIALS,NUMBER OF SUCCESSES,PROB OF SUCCESS
```

DISTRIBUTIONS

POINT HYPERGEOMETRIC DISTRIBUTION

DESCRIPTION

This program calculates the probability that a hypergeometric random variable has the value Y. The random variable represents the number of defectives in sample size M of population size N. K represents defectives in the population, and Y represents defectives in the sample.

The values of N, M, K, and Y are required input.

All probabilities are calculated with minimum six digit accuracy.

HARDWARE REQUIREMENTS

A Tektronix 4050-Series Graphic System is required.

PROGRAM LIMITS

P(X = Y) must be greater than 10^{-300}.

METHODS

All factorials are calculated using Stirlings approximation.

The quantity calculated is:

$$P(X = Y) = \frac{\binom{K}{Y}\binom{N-K}{M-Y}}{\binom{N}{M}}$$

REFERENCE

Abramowitz, M., and Stegun, I. A., editors, *Handbook of Mathematical Functions with Formulas, Graphs, and Mathematical Tables*, Washington, D. C: National Bureau of Standards, Applied Math Series No. 55, Government Printing Office.

POINT HYPERGEOMETRIC DISTRIBUTION

VARIABLES

VARIABLE	USAGE
A1	Scratch
B1	Scratch
K	Number of defectives in the population
M	Sample size
N	Population size
X	Number of defectives in the sample
X1	Scratch
X2	Scratch

PROGRAM LOADING

This program may be loaded automatically from the directory, or manually from the keyboard.

AUTOMATIC LOADING FROM THE DIRECTORY

1. Insert the program tape.
2. Press AUTO LOAD. The program directory will be displayed with the message ENTER THE PROGRAM NUMBER YOU WANT.
3. Enter 10; press RETURN.
4. When the I/O light goes out, execute the program.

MANUAL LOADING FROM THE KEYBOARD

1. Insert the program tape.
2. Enter FIND 11; press RETURN.
3. Enter OLD; press RETURN.
4. When the I/O light goes out, execute the program.

POINT HYPERGEOMETRIC DISTRIBUTION

PROGRAM EXECUTION

1. LOT SIZE is displayed. Enter the population value and press RETURN.
2. SAMPLE SIZE is displayed. Enter the value and press RETURN.
3. NUMBER OF DEFECTIVES IN THE LOT appears on the screen. Enter the value; press RETURN.
4. NUMBER OF DEFECTIVES IN THE SAMPLE is displayed. When the value is entered, press RETURN.
5. The probability is displayed with the values which were entered.
6. Steps 1 through 5 may be repeated for other values, or the program may be terminated by pressing the BREAK key twice.

EXAMPLE

```
                    POINT HYPERGEOMETRIC DISTRIBUTION

LOT SIZE 50
SAMPLE SIZE 24
NUMBER OF DEFECTIVES IN THE LOT 20
NUMBER OF DEFECTIVES IN THE SAMPLE 10
  N=   50  M=   24  K=   20  P(X=   10)=  0.221045


LOT SIZE 560
SAMPLE SIZE 100
NUMBER OF DEFECTIVES IN THE LOT 25
NUMBER OF DEFECTIVES IN THE SAMPLE 13
  N=  560  M=  100  K=   25  P(X=   13)=  0.000061


LOT SIZE
```

SINGLE TERM HYPERGEOMETRIC DISTRIBUTION

DESCRIPTION

This program calculates probabilities for each value of random variable X between the upper and lower limits of Y. X represents the number of defectives in the sample and follows the hypergeometric distribution. Y limits are determined at execution time.

Probabilities are calculated with 10 digit minimum accuracy.

Population size (N), sample size (M), the number of defectives in the lot (K), and the upper and lower limits to the number of defectives in the sample (Y), are the required input values.

Output probabilities are expressed as X = Y, X <= Y, and X > Y.

HARDWARE REQUIREMENTS

A Tektronix 4050-Series Graphic System is required.

PROGRAM LIMITS

When accumulative distribution (X <= Y) is the only output desired, the Accumulative Hypergeometric Distribution program should be used.

METHODS

The hypergeometric function is defined as:

$$P(X = R) = \frac{\binom{N-K}{M-R}\binom{K}{R}}{\binom{N}{M}}.$$

Let R = maximum (0,M+K–N). P(X = R) is first calculated and the recursion relation

$$P(X = J) = \frac{(K-J+1)}{(N-K-M+J)} \cdot \frac{(M-J+1)}{J} \cdot P(X = J-1)$$

is used to calculate other probabilities.

SINGLE TERM HYPERGEOMETRIC DISTRIBUTION

REFERENCE

Mood, A., Graybill, F., Boes, D., *Introduction to the Theory of Statistics*, New York: McGraw-Hill, 1974.

VARIABLES

VARIABLE	USAGE
K	Number of defectives in the population
M	Sample size
N	Population size
T	Scratch
X	Number of defectives in the sample
X1	Scratch
X2	Scratch
X3	Scratch
X4	Scratch
Y1	Scratch
Y2	Scratch

PROGRAM LOADING

This program may be loaded automatically from the directory, or manually from the keyboard.

AUTOMATIC LOADING FROM THE DIRECTORY

1. Insert the program tape.
2. Press AUTO LOAD. The program directory will be displayed with the message ENTER THE PROGRAM NUMBER YOU WANT.
3. Enter 11; press RETURN.
4. When the I/O light goes out, execute the program.

SINGLE TERM HYPERGEOMETRIC DISTRIBUTION

MANUAL LOADING FROM THE KEYBOARD

1. Insert the program tape.
2. Enter FIND 12; press RETURN.
3. Enter OLD; press RETURN.
4. When the I/O light goes out, execute the program.

PROGRAM EXECUTION

1. LOT SIZE appears on the display screen. Enter the lot (population) size and press RETURN.
2. SAMPLE SIZE is now displayed. Enter the sample size; press RETURN.
3. When NUMBER OF DEFECTIVES IN THE LOT is displayed, enter the value and press RETURN.
4. CALCULATE PROBABILITIES FOR NUMBER OF DEFECTIVES IN SAMPLE $>=$ is displayed. This value is the lower limit for probability calculation. Enter the value and press the RETURN key.
5. AND FOR NUMBER OF DEFECTIVES IN SAMPLE $<=$ appears. Enter the upper probability limit and press RETURN.
6. Probabilities for the number of defectives in the sample which are within the limits are printed.
7. To repeat execution of this program, type RUN, press RETURN, and enter new data values.

SINGLE TERM HYPERGEOMETRIC DISTRIBUTION

EXAMPLE 1

For population 40, sample 23, and 12 defectives in the population, calculate probabilities for all possible defectives in the sample.

Set the lower limit at zero and the upper limit high enough to calculate all values. In this example, 12 is the highest possible upper limit value. After all input values have been entered, calculations will be printed when the RETURN key is pressed.

```
                SINGLE TERM HYPERGEOMETRIC DISTRIBUTION
FOR LOT SIZE= 40  SAMPLE SIZE= 23  NUMBER OF DEFECTIVES IN LOT = 12
CALCULATED FOR NUMBER DEFECTIVES IN SAMPLE BETWEEN  0 AND 12
        N     M     Y    P(X=Y)     P(X<=Y)    P(X>Y)
       40    23     0   0.000001   0.000001   0.999999
       40    23     1   0.000051   0.000052   0.999948
       40    23     2   0.000881   0.000933   0.999067
       40    23     3   0.007706   0.008639   0.991361
       40    23     4   0.038531   0.047170   0.952830
       40    23     5   0.117133   0.164303   0.835697
       40    23     6   0.223618   0.387921   0.612079
       40    23     7   0.271536   0.659456   0.340544
       40    23     8   0.208874   0.868330   0.131670
       40    23     9   0.099464   0.967794   0.032206
       40    23    10   0.027850   0.995644   0.004356
       40    23    11   0.004114   0.999758   0.000242
       40    23    12   0.000242   1.000000   0.000000
```

SINGLE TERM HYPERGEOMETRIC DISTRIBUTION

EXAMPLE 2

The lot size is 500, the sample size is 50, and there are 100 defectives in the lot. Calculate probabilities for all possible number of defectives in the sample with non-zero probabilities.

Since the non-zero probability limits are unknown, arbitrary limit assignments are made. In this example, limits of 10 and 40 were chosen. When the RETURN key is pressed, the calculated results will appear on the screen.

```
                SINGLE TERM HYPERGEOMETRIC DISTRIBUTION
FOR LOT SIZE= 500  SAMPLE SIZE= 50  NUMBER OF DEFECTIVES IN LOT = 100
CALCULATED FOR NUMBER DEFECTIVES IN SAMPLE BETWEEN  10 AND 40
        N     M     Y    P(X=Y)      P(X<=Y)     P(X>Y)
      500    50    10   0.147368    0.585148    0.414852
      500    50    11   0.133600    0.718748    0.281252
      500    50    12   0.106751    0.825499    0.174501
      500    50    13   0.075646    0.901145    0.098855
      500    50    14   0.047784    0.948928    0.051072
      500    50    15   0.027021    0.975949    0.024051
      500    50    16   0.013727    0.989676    0.010324
      500    50    17   0.006284    0.995960    0.004040
      500    50    18   0.002598    0.998558    0.001442
      500    50    19   0.000972    0.999531    0.000469
      500    50    20   0.000330    0.999861    0.000139
      500    50    21   0.000102    0.999962    0.000038
      500    50    22   0.000028    0.999991    0.000009
      500    50    23   0.000007    0.999998    0.000002
      500    50    24   0.000002    1.000000    0.000000
      500    50    25   0.000000    1.000000    0.000000
      500    50    26   0.000000    1.000000    0.000000
      500    50    27   0.000000    1.000000    0.000000
      500    50    28   0.000000    1.000000    0.000000
      500    50    29   0.000000    1.000000    0.000000
      500    50    30   0.000000    1.000000    0.000000
      500    50    31   0.000000    1.000000    0.000000
      500    50    32   0.000000    1.000000    0.000000
      500    50    33   0.000000    1.000000    0.000000
      500    50    34   0.000000    1.000000    0.000000
      500    50    35   0.000000    1.000000    0.000000
      500    50    36   0.000000    1.000000    0.000000
      500    50    37   0.000000    1.000000    0.000000
      500    50    38   0.000000    1.000000    0.000000
      500    50    39   0.000000    1.000000    0.000000
      500    50    40   0.000000    1.000000    0.000000
```

The table printed above indicates that the lower limit (10) is not low enough and that an upper limit of 25 is correct.

SINGLE TERM HYPERGEOMETRIC DISTRIBUTION

When limits are set between 0 and 25, non-zero probabilities are shown as:

SINGLE TERM HYPERGEOMETRIC DISTRIBUTION
FOR LOT SIZE= 500 SAMPLE SIZE= 50 NUMBER OF DEFECTIVES IN LOT = 100
CALCULATED FOR NUMBER DEFECTIVES IN SAMPLE BETWEEN 0 AND 25

N	M	Y	P(X=Y)	P(X<=Y)	P(X>Y)
500	50	0	0.000007	0.000007	0.999993
500	50	1	0.000105	0.000112	0.999888
500	50	2	0.000723	0.000835	0.999165
500	50	3	0.003209	0.004044	0.995956
500	50	4	0.010333	0.014377	0.985623
500	50	5	0.025707	0.040084	0.959916
500	50	6	0.051450	0.091534	0.908466
500	50	7	0.085153	0.176687	0.823313
500	50	8	0.118899	0.295587	0.704413
500	50	9	0.142194	0.437781	0.562219
500	50	10	0.147368	0.585148	0.414852
500	50	11	0.133600	0.718748	0.281252
500	50	12	0.106751	0.825499	0.174501
500	50	13	0.075646	0.901145	0.098855
500	50	14	0.047784	0.948928	0.051072
500	50	15	0.027021	0.975949	0.024051
500	50	16	0.013727	0.989676	0.010324
500	50	17	0.006284	0.995960	0.004040
500	50	18	0.002598	0.998558	0.001442
500	50	19	0.000972	0.999531	0.000469
500	50	20	0.000330	0.999861	0.000139
500	50	21	0.000102	0.999962	0.000038
500	50	22	0.000028	0.999991	0.000009
500	50	23	0.000007	0.999998	0.000002
500	50	24	0.000002	1.000000	0.000000
500	50	25	0.000000	1.000000	0.000000

ACCUMULATIVE HYPERGEOMETRIC DISTRIBUTION

DESCRIPTION

This program calculates the probability that Y is less than or equal to R. Y is a random variable following the hypergeometric distribution, and R is a selected number of defectives in the sample.

The accumulative probability is calculated with a minimum of 10 significant figures of accuracy.

Lot size (N), sample size (M), number of defectives in the lot (K), and number of defectives for which probability will be calculated (R), are required input.

HARDWARE REQUIREMENTS

A Tektronix 4050-Series Graphic System is required.

METHODS

Sterlings approximation is used to calculate P(Y = R).

The recursion relation is

$$P(Y = j-1) = \frac{(Y-j-1)}{(M-Y+1-j)} \frac{(N-M-K+Y-j-1)}{(K-X+1-j)} \cdot P(Y = j)$$

is used to calculate lower order probabilities.

REFERENCE

Mood, A., Graybill, F., Boes, D., *Introduction of the Theory of Statistics*, New York: McGraw-Hill, 1974.

ACCUMULATIVE HYPERGEOMETRIC DISTRIBUTION

VARIABLES

VARIABLE	USAGE
A	Scratch
A1	Scratch
A2	Scratch
A3	Scratch
B1	Scratch
B2	Scratch
K	Number of defectives in population
M	Sample size
N	Population size
X	Number of defectives in sample
X1	Scratch
X2	Scratch

PROGRAM LOADING

This program may be loaded automatically from the directory, or manually from the keyboard.

AUTOMATIC LOADING FROM THE DIRECTORY

1. Insert the program tape.
2. Press AUTO LOAD. The program directory will be displayed with the message ENTER THE PROGRAM NUMBER YOU WANT.
3. Enter 12; press RETURN.
4. When the I/O light goes out, execute the program.

MANUAL LOADING FROM THE KEYBOARD

1. Insert the program tape.
2. Enter FIND 13; press RETURN.
3. Enter OLD; press RETURN.
4. When the I/O light goes out, execute the program.

ACCUMULATIVE HYPERGEOMETRIC DISTRIBUTION

PROGRAM EXECUTION

1. When LOT SIZE is displayed, enter the population value and press RETURN.
2. SAMPLE SIZE indicates that the sample value is needed. Enter the value and press RETURN.
3. NUMBER OF DEFECTIVES IN LOT appears. Type the value and press RETURN.
4. CALCULATE PROBABILITY OF NUMBER OF DEFECTIVES IN SAMPLE <= requests the final required value. Enter the value; press RETURN.
5. Input values and calculated probability will appear on the screen.
6. Repeat the program execution sequence for other values, or press BREAK twice to exit from the program.

EXAMPLE

For lot size 50, sample size 23, and 12 defectives in the lot, find the probability that the sample will contain 6 defectives or less.

```
                    ACCUMULATIVE HYPERGEOMETRIC DISTRIBUTION
LOT SIZE 50
SAMPLE SIZE 23
NUMBER OF DEFECTIVES IN LOT 12
CALCULATE PROBABILITY OF NUMBER OF DEFECTIVES IN SAMPLE <= 6
 N=     50 M=     23 K=     12  P(X<=    6)=  0.742781

LOT SIZE
```

SINGLE TERM POISSON DISTRIBUTION

DESCRIPTION

This program calculates probabilities for a random variable following the Poisson distribution with rate parameter (mean) lambda. Probabilities are calculated for each value between specified lower and upper limits. Accumulative and right tail probability are also calculated.

The values of the mean and the lower and upper limits must be entered.

HARDWARE REQUIREMENTS

A Tektronix 4050-Series Graphic System is required.

PROGRAM LIMITS

The rate parameter must be positive.

METHODS

With non-negative integer r and rate parameter m, the Poisson distribution is defined by

$$P(X = r) = e^{-m} \frac{m^r}{r!}$$

REFERENCE

Mood, A., Graybill, F., Boes, D., *Introduction to the Theory of Statistics*, New York: McGraw-Hill, 1974.

VARIABLES

VARIABLE	USAGE
A	Accumulative probability
E	Exp (– lambda)
I	Counter
N1	Lower limit
N2	Upper limit
S	Scratch
S1	Scratch
Y	Mean lambda

SINGLE TERM POISSON DISTRIBUTION

PROGRAM LOADING

This program may be loaded automatically from the directory, or manually from the keyboard.

AUTOMATIC LOADING FROM THE DIRECTORY

1. Insert the program tape.
2. Press AUTO LOAD. The program directory will be displayed with the message ENTER THE PROGRAM NUMBER YOU WANT.
3. Enter 13; press RETURN.
4. When the I/O light goes out, execute the program.

MANUAL LOADING FROM THE KEYBOARD

1. Insert the program tape.
2. Enter FIND 14; press RETURN.
3. Enter OLD; press RETURN.
4. When the I/O light goes out, execute the program.

PROGRAM EXECUTION

1. LAMBDA is displayed. Enter the value of the mean and press RETURN.
2. CALCULATE PROBABILITIES:

   FROM LOWER LIMIT appears on the screen. Enter the smallest value for which probability is to be calculated. Press RETURN.
3. TO UPPER LIMIT is displayed. Enter the largest value for probability calculation and press RETURN.
4. Probabilities are displayed for all values within the limits.
5. Program execution may be repeated by typing RUN, pressing RETURN, and entering other data values.

SINGLE TERM POISSON DISTRIBUTION

EXAMPLE 1

For a Poisson variable with mean 4, calculate probabilities for values from zero to 10.

SINGLE TERM POISSON DISTRIBUTION

LAMBDA = 4

Y	P(X=Y)	P(X<=Y)	P(X>Y)
0	0.018316	0.018316	0.981684
1	0.073263	0.091578	0.908422
2	0.146525	0.238103	0.761897
3	0.195367	0.433470	0.566530
4	0.195367	0.628837	0.371163
5	0.156293	0.785130	0.214870
6	0.104196	0.889326	0.110674
7	0.059540	0.948866	0.051134
8	0.029770	0.978637	0.021363
9	0.013231	0.991868	0.008132
10	0.005292	0.997160	0.002840

EXAMPLE 2

For a Poisson variable with mean 6.2, calculate the probabilities of values between 2 and 18.

SINGLE TERM POISSON DISTRIBUTION

LAMBDA = 6.2

Y	P(X=Y)	P(X<=Y)	P(X>Y)
2	0.039006	0.053618	0.946382
3	0.080612	0.134229	0.865771
4	0.124948	0.259177	0.740823
5	0.154936	0.414113	0.585887
6	0.160100	0.574213	0.425787
7	0.141803	0.716016	0.283984
8	0.109897	0.825914	0.174086
9	0.075707	0.901621	0.098379
10	0.046938	0.948559	0.051441
11	0.026456	0.975015	0.024985
12	0.013669	0.988684	0.011316
13	0.006519	0.995203	0.004797
14	0.002887	0.998090	0.001910
15	0.001193	0.999284	0.000716
16	0.000462	0.999746	0.000254
17	0.000169	0.999915	0.000085
18	0.000058	0.999973	0.000027

HIGH ACCURACY NORMAL DISTRIBUTION

DESCRIPTION

This program calculates right tail probability for the normal distribution. Probabilities are computed with at least 10 digit accuracy. A normal deviate value is the only required input.

HARDWARE REQUIREMENTS

A Tektronix 4050-Series Graphic System is required.

PROGRAM LIMITS

Normal deviate values must be positive.

For normal deviates greater than 20, the log to base 10 of the normal probability is printed.

METHODS

An infinite series is used to calculate probability for normal deviates of 3.5 or less. When the deviate is greater than 3.5, Gauss's continued fraction is used.

REFERENCE

Abramowitz, M., and Stegun, I. A., editors, *Handbook of Mathematical Functions with Formulas, Graphs, and Mathematical Tables*, Washington, D. C: National Bureau of Standards, Applied Math Series No. 55, Government Printing Office.

VARIABLES

VARIABLE	USAGE
A1	Scratch
A2	Scratch
B1	Scratch
B2	Scratch
I	Counter
X	Absolute value of normal deviate
Y	Scratch
Y1	Scratch
Z	Scratch

HIGH ACCURACY NORMAL DISTRIBUTION

PROGRAM LOADING

This program may be loaded automatically from the directory, or manually from the keyboard.

AUTOMATIC LOADING FROM THE DIRECTORY

1. Insert the program tape.
2. Press AUTO LOAD. The program directory will be displayed with the message ENTER THE PROGRAM NUMBER YOU WANT.
3. Enter 14; press RETURN.
4. When the I/O light goes out, execute the program.

MANUAL LOADING FROM THE KEYBOARD

1. Insert the program tape.
2. Enter FIND 15; press RETURN.
3. Enter OLD; press RETURN.
4. When the I/O light goes out, execute the program.

PROGRAM EXECUTION

1. X is displayed on the screen. Enter the value for the positive normal deviate; press RETURN.
2. The right tail probability is displayed.
3. Another value may be entered, or the program may be terminated by pressing the BREAK key twice.

HIGH ACCURACY NORMAL DISTRIBUTION

EXAMPLE

```
                    HIGH ACCURACY NORMAL DISTRIBUTION

X 1.2
P(X>1.2) =0.115069670222

X 2.6
P(X>2.6) =0.0046611880236

X 9.4
P(X>9.4) = 2.728153571E-21

X -1
P(X>1) =0.158655253932

X 27
LOG(P(X>27)) = -160.131386062

X
```

F-TABLED

DESCRIPTION

This program calculates the tabled value for an F-Distribution with degrees of freedom N and D, and right tail probability P. The program is the inverse of the F-Distribution program in the DISTRIBUTIONS section.

Accuracy is calculated to a minimum of 6 digits for significance levels between .0001 and .9999.

Degrees of freedom and significance level (right tail probability) are required input.

HARDWARE REQUIREMENTS

A Tektronix 4050-Series Graphic System is required.

PROGRAM LIMITS

Degrees of freedom must be greater than .1, and the significance level must be between .0001 and .9999.

METHODS

The F-distribution is transformed to a beta distribution and a tabled beta estimate is calculated. A quasi-linear interpolation scheme uses this estimate to solve for the tabled beta value. The tabled beta value is then transformed to a tabled F value (Reference 2).

REFERENCES

1. Aroian, T. A., "Continued Fractions for the Incomplete Beta Function", *Annals of Mathematical Statistics*, 12 (1941), pp. 218–223.
2. Kopitzke, R. W., "Unpublished Notes."
3. Peizer, D. B., Pratt, J. W., "A Normal Approximation for Binomial, F, Beta, and Other Common Related Tail Probabilities, I" *Journal of the American Statistical Association*, 63 (1968), pp. 1457–1483.

TABLED VALUES

F-TABLED

VARIABLES

VARIABLE	USAGE
A	Numerator degrees of freedom/2
A1	Scratch
A2	Scratch
B	Denominator degrees of freedom/2
B1	Scratch
B2	Scratch
F1	Numerator degrees of freedom
F2	Denominator degrees of freedom
I	Counter
P	Significance level
P0	Scratch
P1	Scratch
Q	Value of beta function
T	Scratch
T7	Scratch
T8	Scratch
U	Scratch
V	Scratch
V1	Scratch
X	Scratch
X1	Approximate root
X2	Approximate root
X3	Approximate root
Y	Scratch
Y1	Scratch
Y2	Scratch
Y4	Scratch

F-TABLED

PROGRAM LOADING

This program may be loaded automatically from the directory, or manually from the keyboard.

AUTOMATICALLY LOADING FROM THE DIRECTORY

1. Insert the program tape.
2. Press AUTO LOAD. The program directory will be displayed with the message ENTER THE PROGRAM NUMBER YOU WANT.
3. Enter 15, press RETURN.
4. When the I/O light goes out, execute the program.

MANUAL LOADING FROM THE KEYBOARD

1. Insert the program tape.
2. Enter FIND 16; press RETURN.
3. Enter OLD; press RETURN.
4. When the I/O light goes out, execute the program.

PROGRAM EXECUTION

1. NUM DF, DEN DF, SIG LEVEL is displayed. Enter the values and press RETURN. Commas should be used to separate values being entered.
2. The tabled value is displayed.
3. The program may be repeated by entering new values. To exit from the program, press BREAK twice.

EXAMPLE

```
                    F TABLED

NUM DF, DEN DF,SIG LEVEL 2,2,.05
NUM DF=2 DEN DF=2 SIG LEVEL=0.05 TABLED F=19

NUM DF, DEN DF,SIG LEVEL 25,63,.01
NUM DF=25 DEN DF=63 SIG LEVEL=0.01 TABLED F=2.08228446

NUM DF, DEN DF,SIG LEVEL 25,63,.9999
NUM DF=25 DEN DF=63 SIG LEVEL=0.9999 TABLED F=0.238842268

NUM DF, DEN DF,SIG LEVEL 5000,5000,.6
NUM DF=5000 DEN DF=5000 SIG LEVEL=0.6 TABLED F=0.992859511

NUM DF, DEN DF,SIG LEVEL
```

TABLED VALUES

t-TABLED

DESCRIPTION

This program calculates the tabled value for a Student's t distribution and is the inverse of the t-Distribution program in Section 1. Accuracy is calculated to a 5 digit minimum.

Input values are degrees of freedom and significance level for a one-tail test.

HARDWARE REQUIREMENTS

A Tektronix 4050-Series Graphic System is required.

PROGRAM LIMITS

Degrees of freedom must be greater than .1.

Significance level must be between .0005 and .5.

METHODS

The t-distribution is transformed to a beta distribution, and an initial estimate of the tabled beta value is calculated. A quasi-linear interpolation scheme solves for the tabled beta value which is then transformed to t-tabled value.

REFERENCES

1. Aroian, T. A., "Continued Fractions for the Incomplete Beta Function"; *Annals of Mathematical Statistics*, 12 (1941), pp. 218–223.

2. Kopitzke, R. W., "Unpublished Notes."

3. Peizer, D. B., Pratt, J. W., "A Normal Approximation for Binomial, F, Beta, and Other Common Related Tail Probabilities, I" *Journal of the American Statistical Association*, 63 (1968), pp. 1457–1483.

VARIABLES

VARIABLE	USAGE
A	Degrees of freedom/2
A1	Scratch
A2	Scratch
B	Scratch
B1	Scratch
B2	Scratch
F1	Degrees of freedom
I	Counter
P	Significance level
P0	Significance level
P1	Scratch
Q	Point at which to evaluate beta
T	Scratch
T7	Scratch
T8	Scratch
U	Scratch
V	Scratch
V1	Scratch
X	Scratch
X1	Approximate root
X2	Approximate root
X3	Approximate root
Y1	Scratch
Y2	Scratch
Y4	Log of beta function

TABLED VALUES

t-TABLED

PROGRAM LOADING

This program may be loaded automatically from the directory, or manually from the keyboard.

AUTOMATIC LOADING FROM THE DIRECTORY

1. Insert the program tape.
2. Press AUTO LOAD. The program directory will be displayed with the message ENTER THE PROGRAM NUMBER YOU WANT.
3. Enter 16; press RETURN.
4. When the I/O light goes out, execute the program.

MANUAL LOADING FROM THE KEYBOARD

1. Insert the program tape.
2. Enter FIND 17; press RETURN.
3. Enter OLD; press RETURN.
4. When the I/O light goes out, execute the program.

PROGRAM EXECUTION

1. DEGREES OF FREEDOM, SIG LEVEL is displayed. Enter degrees of freedom, a comma, and significance level. Press RETURN.
2. Input and t-tabled values are displayed.
3. Enter other values to repeat execution of the program, or press BREAK twice to exit.

EXAMPLE

```
                    T TABLED

DEGREES OF FREEDOM,SIG LEVEL 16,.01
DEGREES OF FREEDOM=16  SIG LEVEL=0.01  TABLED T=2.583487

DEGREES OF FREEDOM,SIG LEVEL 1700,.05
DEGREES OF FREEDOM=1700  SIG LEVEL=0.05  TABLED T=1.64575

DEGREES OF FREEDOM,SIG LEVEL 12,.5

DEGREES OF FREEDOM,SIG LEVEL 12,.2
DEGREES OF FREEDOM=12  SIG LEVEL=0.2  TABLED T=0.87261

DEGREES OF FREEDOM,SIG LEVEL
```

CHI-SQUARE TABLED

DESCRIPTION

This program calculates the tabled value for a chi-square distribution and is the inverse of the chi-square distribution program described in Section 1.

Degrees of freedom and the significance level for a one-tail test are required input values.

The tabled value has a minimum of five digits of accuracy.

HARDWARE REQUIREMENTS

A Tektronix 4050-Series Graphic System is required.

PROGRAM LIMITS

The degrees of freedom must be greater than 0.1 and the significance level must be between .0005 and .9995.

METHODS

An approximate tabled value is obtained using the Wilson-Hilferty approximation (Reference 1, equation 26.4.17). A Newton-Raphson iteration scheme is then employed until the tabled value is bracketed above and below. A quasi-linear interpolation scheme uses these two bracketing points until the tabled value is found.

REFERENCES

1. Abramowitz, M., and Stegun, I. A., editors, *Handbook of Mathematical Functions with Formulas, Graphs, and Mathematical Tables,* National Bureau of Standards Applied Mathematics Series No. 55, Washington, D. C: Government Printing Office.

2. Khovanskii, A. N., *The Applications of Continued Fractions and Their Generalizations to Problems in Approximation Theory*, translated by P. Wynn, P. Noordhoff, Groningen: 1963.

3. Peizer, D. B., Pratt, J. W., "A Normal Approximation for Binomial, F, Beta, and Other Common, Related, Trail Probabilities I", *Journal of the American Statistical Association*, 63, 1968, pp. 1416–1456.

4. Wall, H. S., *Analytic Theory of Continued Fractions,* New York; D. Van Nostrand, 1948.

TABLED VALUES

CHI-SQUARE TABLED

VARIABLES

VARIABLE	USAGE
A	Degrees of freedom/2
A1	Scratch
A2	Scratch
B	Final root
B1	Scratch
B2	Scratch
C1	Scratch
I	Counter
N	Degrees of freedom
P	Significance level
P1	Scratch
P2	Scratch
T	Scratch
X	Scratch
X1	Scratch
X2	Scratch
X8	Scratch
Y1	Scratch
Y2	Scratch
Z	Scratch

PROGRAM LOADING

This program may be loaded automatically from the directory, or manually from the keyboard.

AUTOMATIC LOADING FROM THE DIRECTORY

1. Insert the program tape.
2. Press AUTO LOAD. The program directory will be displayed with the message ENTER THE PROGRAM NUMBER YOU WANT.
3. Enter 17; press RETURN.
4. When the I/O light goes out, execute the program.

CHI-SQUARE TABLED

MANUAL LOADING FROM THE KEYBOARD

1. Insert the program tape.
2. Enter FIND 18; press RETURN.
3. Enter OLD; press RETURN.
4. When the I/O light goes out, execute the program.

PROGRAM EXECUTION

1. DEG FREEDOM, SIG LEVEL is displayed. Enter the degrees of freedom, a comma, and the significance level. Press RETURN.

2. The Chi-square tabled value is displayed with the input values.

3. Repeat the program execution by entering new values, or exit from the program by pressing the BREAK key twice.

EXAMPLE

```
                    CHI SQUARE TABLED

DEG FREEDOM,SIG LEVEL 50,.05
FOR DF=50 SIG LEVEL=0.05 CHI SQUARE TABLED=67.5048

DEG FREEDOM,SIG LEVEL 4,.9999
FOR DF=4 SIG LEVEL=0.9999 CHI SQUARE TABLED=0.02841848

DEG FREEDOM,SIG LEVEL 15000,.2
FOR DF=15000 SIG LEVEL=0.2 CHI SQUARE TABLED=15145.574

DEG FREEDOM,SIG LEVEL
```

TABLED VALUES

GAMMA TABLED

DESCRIPTION

This program calculates the tabled value for a two parameter gamma distribution with right tail probability. It is the inverse of the gamma distribution program and calculates the tabled value with a minimum five digit accuracy.

Parameters and right tail probability are required input values and are displayed with the calculated tabled value.

HARDWARE REQUIREMENTS

A Tektronix 4050-Series Graphic System is required.

PROGRAM LIMITS

The ratio of parameter a to parameter b should be greater than 0.1.

Right tail probability should be between .0005 and .9995.

METHODS

An approximate tabled value is obtained using the Wilson-Hilferty approximation (Reference 1, equation 26.4.17). A Newton-Raphson iteration scheme is used until the tabled value is bracketed above and below. A quasi-linear interpolation scheme uses these two bracketing points to find the tabled value.

REFERENCES

1. Abramowitz, M., and Stegun, I. A., editors, *Handbook of Mathematical Functions With Formulas, Graphs, and Mathematical Tables,* National Bureau of Standards Applied Mathematics Series No. 55, Washington, D. C: Government Printing Office.

2. Khovanskii, A. N., *The Applications of Continued Fractions and Their Generalizations to Problems in Approximation Theory,* translated by P. Wynn, 1963, Groningen: P. Noordhoff.

3. Peizer, D. B., Pratt, J. W., "A Normal Approximation for Binomial, F, Beta, and Other Common, Related, Tail Probabilities I", *Journal of the American Statistical Association,* 63, 1968, pp. 1416–1456.

4. Wall, H. S., *Analytic Theory of Continued Fractions,* New York: D. Van Nostrand, 1948.

GAMMA TABLED

VARIABLES

VARIABLE	USAGE
A	Parameter a
A1	Scratch
A2	Scratch
B	Final root
B1	Scratch
B2	Scratch
C1	Scratch
C2	Parameter b
I	Counter
N	Parameter a
P	Right tail probability
P1	Scratch
P2	Scratch
T	Scratch
X	Scratch
X1	Approximate root
X2	Approximate root
X8	Scratch
Y1	Scratch
Y2	Scratch
Z	Scratch

TABLED VALUES

GAMMA TABLED

PROGRAM LOADING

This program may be loaded automatically from the directory, or manually from the keyboard.

AUTOMATIC LOADING FROM THE DIRECTORY

1. Insert the program tape.
2. Press AUTO LOAD. The program directory will be displayed with the message ENTER THE PROGRAM NUMBER YOU WANT.
3. Enter 18; press RETURN.
4. When the I/O light goes out, execute the program.

MANUAL LOADING FROM THE KEYBOARD

1. Insert the program tape.
2. Enter FIND 19; press RETURN.
3. Enter OLD; press RETURN.
4. When the I/O light goes out, execute the program.

PROGRAM EXECUTION

1. A, B, RIGHT TAIL PROB is displayed. Enter the values (separated by commas) and press RETURN.
2. The input values and the tabled value are displayed.
3. Enter the new input values to execute the program again, or press the BREAK key twice to exit from the program.

EXAMPLE

```
                    GAMMA TABLED

A,B,RIGHT TAIL PROB 56,2,.1
A=56  B=2  RT TAIL PROB=0.1  GAMMA TABLED=69.918511

A,B,RIGHT TAIL PROB 12,2.35,.8
A=12  B=2.35  RT TAIL PROB=0.8  GAMMA TABLED=7.4618437

A,B,RIGHT TAIL PROB 6.23,3.21,.75
A=6.23  B=3.21  RT TAIL PROB=0.75  GAMMA TABLED=2.9466713

A,B,RIGHT TAIL PROB
```

NORMAL TABLED

DESCRIPTION

This program will calculate an approximate tabled value for the normal distribution. The right tail probability is required input. Tabled value and the probability are displayed as output.

The tabled value is calculated with a maximum absolute error of 1.4×10^{-6} for the right tail probabilities between .01 and .99. For right tail probabilities between .0001 and .01, or between .99 and .9999, maximum error is 5×10^{-5}.

HARDWARE REQUIREMENTS

A Tektronix 4050-Series Graphic System is required.

METHODS

An approximate formula (Reference 1, equation 26.2.23) is used to obtain an initial estimate. A one step iteration method based upon Reference 2 is then used to improve the accuracy.

REFERENCES

1. Abramowitz, M., and Stegun, I. A., editors, *Handbook of Mathematical Functions with Formulas, Graphs, and Mathematical Tables*, National Bureau of Standards Applied Mathematics Series No. 55, Washington, D. C: Government Printing Office.

2. Hill, G. W., and Davis, A. W., "Generalized Asymptotic Expansions of Cornish-Fisher Type", *Annals of Mathematical Statistics*, 39, 1968, pp. 1264–1273.

VARIABLES

VARIABLE	USAGE
P	Significance level
T	Scratch
X	Scratch
Y	Tabled normal

TABLED VALUES

NORMAL TABLED

PROGRAM LOADING

This program may be loaded automatically from the directory, or manually from the keyboard.

AUTOMATIC LOADING FROM THE DIRECTORY

1. Insert the program tape.
2. Press AUTO LOAD. The program directory will be displayed with the message ENTER THE PROGRAM NUMBER YOU WANT.
3. Enter 19, press RETURN.
4. When the I/O light goes out, execute the program.

MANUAL LOADING FROM THE KEYBOARD

1. Insert the program tape.
2. Enter FIND 20; press RETURN.
3. Enter OLD; press RETURN.
4. When the I/O light goes out, execute the program.

PROGRAM EXECUTION

1. RIGHT TAIL PROBABILITY is displayed. Enter the probability value and press RETURN.
2. The probability and tabled value are displayed.
3. Other values may be entered to repeat execution of the program, or an exit may be called by pressing BREAK twice.

EXAMPLE

```
                    NORMAL TABLED

RIGHT TAIL PROBABILITY .05
P(X)  1.644600 )=  0.05000000

RIGHT TAIL PROBABILITY .01
P(X)  2.306623 )=  0.01000000

RIGHT TAIL PROBABILITY .025
P(X)  1.957355 )=  0.02500000

RIGHT TAIL PROBABILITY .0001
P(X)  2.998601 )=  0.00010000

RIGHT TAIL PROBABILITY
```

BETA TABLED

DESCRIPTION

This program calculates the tabled value for a beta distribution and is the inverse of the Beta Distribution program in the DISTRIBUTIONS section.

Parameters a and b and the right tail probability are required input values.

The tabled value is calculated to a minimum 5 digit accuracy.

HARDWARE REQUIREMENTS

A Tektronix 4050-Series Graphic System is required.

PROGRAM LIMITS

Parameters a and b must be greater than 0.01 for all values of P between .0005 and .9995.

METHODS

An initial estimate for the tabled value is calculated. A quasi-linear interpolation scheme then uses the estimate to calculate the tabled value.

REFERENCES

1. Aroian, T. A., "Continued Fractions for the Incomplete Beta Function", *Annals of Mathematical Statistics*, 12 (1941), pp. 218–223.

2. Kopitzke, R. W., "Unpublished Notes."

3. Peizer, D. B., Pratt, J. W., "A Normal Approximation for Binomial, F, Beta, and Other Common Related Tail Probabilities, I" *Journal of the American Statistical Association,* 63 (1968), pp. 1457–1483.

TABLED VALUES

BETA TABLED

VARIABLES

VARIABLE	USAGE
A	Scratch
A1	Scratch
A2	Scratch
B	Scratch
B1	Scratch
B2	Scratch
F1	Parameter a
F2	Parameter b
I	Counter
P	Right tail probability
P0	Scratch
P1	Scratch
Q	Tabled beta
T	Scratch
T7	Flag
T8	Flag
U	Scratch
V	Scratch
V1	Scratch
X	Scratch
X1	Approximate root
X2	Approximate root
X3	Approximate root
Y	Scratch
Y1	Scratch
Y2	Scratch
Y3	Scratch

BETA TABLED

PROGRAM LOADING

This program may be loaded automatically from the directory, or manually from the keyboard.

AUTOMATIC LOADING FROM THE DIRECTORY

1. Insert the program tape.
2. Press AUTO LOAD. The program directory will be displayed with the message ENTER THE PROGRAM NUMBER YOU WANT.
3. Enter 20; press RETURN.
4. When the I/O light goes out, execute the program.

MANUAL LOADING FROM THE KEYBOARD

1. Insert the program tape.
2. Enter FIND 21; press RETURN.
3. Enter OLD; press RETURN.
4. When the I/O light goes out, execute the program.

PROGRAM EXECUTION

1. A, B, RT TAIL PROBABILITY is displayed. Enter the values, using commas to separate the entries.

2. Input and tabled beta values are displayed.

3. The program may be executed repeatedly by entering other values, or an exit may be called by pressing the BREAK key twice.

EXAMPLE

```
                    BETA TABLED

A,B,RT TAIL PROBABILITY 5.63,2.48,.6
A=5.63   B=2.48   RT TAIL PROB=0.6  TABLED BETA=0.2490291

A,B,RT TAIL PROBABILITY 59,1.56,.3
A=59   B=1.56   RT TAIL PROB=0.3  TABLED BETA=0.031645

A,B,RT TAIL PROBABILITY 18,28,.01
A=18   B=28   RT TAIL PROB=0.01  TABLED BETA=0.7652199

A,B,RT TAIL PROBABILITY
```

TABLED VALUES

R BY C CONTINGENCY TABLED

DESCRIPTION

This program performs a contingency table analysis on a two way table. The null hypothesis tested is that the rows and columns are independent, against an alternative hypothesis of dependency.

The number of rows and columns and all observed frequencies are required input values. All input data may be edited.

Any or all of the following output options may be selected:

1. List of data;
2. Column numbers, totals, and probabilities;
3. Row members, totals, and probabilities;
4. Overall total;
5. Expected cell frequencies; and
6. Pearsons coefficient of contingency, number of cells with expected number less than 5, number of cells with expected number less than 1, and chi-square test with degrees of freedom and significance level.

HARDWARE REQUIREMENTS

A Tektronix 4050-Series Graphic System is required. If the Data Communications Interface (Option 1) is installed, minimum acceptable memory configuration is 16K bytes.

METHODS

The formulae below are applied for a contingency table with c columns, r rows, and n observations:

n_{ij} = observed frequency in row i, column j.

$n_{\cdot j}$ = total of column j = $n_{1j} + n_{2j} + \ldots + n_{rj}$.

$n_{i\cdot}$ = total of row i = $n_{i1} + n_{i2} + \ldots + n_{ic}$.

e_{ij} = expected number of row i, column j = $(n_{i\cdot} \cdot n_{\cdot j})/n$

chi-square = $X = (nij - eij)^2/eij$

coefficient of contingency =

$$\sqrt{\frac{X}{n+X}} .$$

degrees of freedom = $(r - 1)(c - 1)$.

R BY C CONTINGENCY TABLED

REFERENCES

1. Mood, A., Graybill, F., Boes, D., *Introduction to the Theory of Statistics,* New York: McGraw-Hill, 1974.

2. Siegel, S., *Non-Parametric Statistics for the Behavioral Sciences,* New York: McGraw-Hill, 1966.

3. Kendall, M. G., and Stuart, A., *The Advanced Theory of Statistics,* New York: Hafner Publishing Company, 1973.

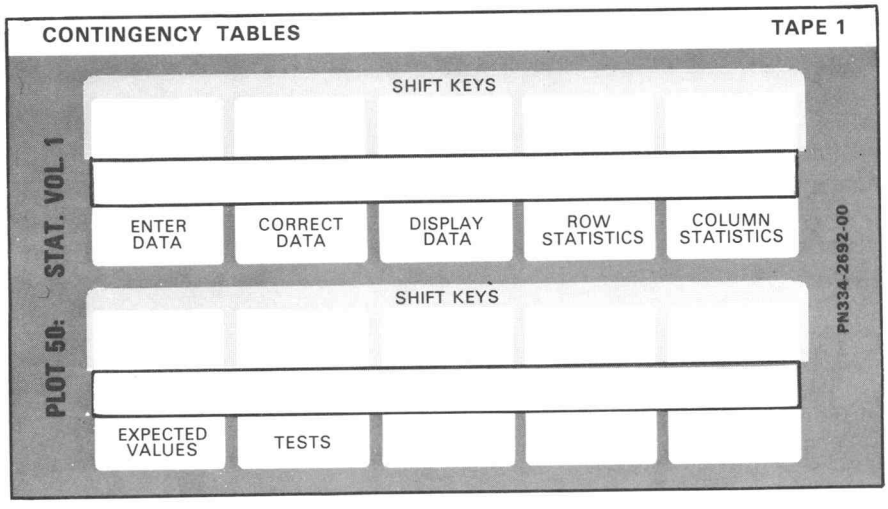
VARIABLES

VARIABLE	USAGE
C	Number of columns in the table
CO	Scratch
C1	Actual number of columns in the table with allowance for totals. (C+1)
C2	Scratch
C3	$P(X^2,DF)$
C4	Scratch
C5	Number of cells with expected value less than 5.
C6	Chi-square
C7	Number of cells with expected value less than 1.
C8	Scratch
C$	Scratch
D	The contingency table (F1,C1)
D1	Scratch
D2	Scratch
D3	Scratch
D4	Scratch
D5	Scratch
D6	Coefficient of contingency
D7	Scratch
D8	Degrees of freedom
D9	Scratch
F	Number of rows in the table
F1	Actual number of rows in the table with allowance for totals. (f+1)

TABLED VALUES

R BY C CONTINGENCY TABLED

FUNCTION KEYS



KEY No.	KEY NAME	FUNCTION
1	ENTER DATA	allows entry of data from keyboard.
2	CORRECT DATA	permits correction of incorrectly entered data.
3	DISPLAY DATA	displays data which has been entered.
4	ROW STATISTICS	calculates and displays row statistics.
5	COLUMN STATISTICS	calculates and displays column statistics.
6	EXPECTED VALUES	calculates and prints the expected number of observations for each cell.
7	TESTS	calculated and displays chi-square test of independence, degrees of freedom, significance level, Pearsons coefficient of contingency, and the number of cells with expected values less than 5 and less than 1.

R BY C CONTINGENCY TABLED

PROGRAM LOADING

This program may be loaded automatically from the directory, or manually from the keyboard.

AUTOMATIC LOADING FROM THE DIRECTORY

1. Insert the program tape.
2. Press AUTO LOAD. The program directory will be displayed with the message ENTER THE PROGRAM NUMBER YOU WANT.
3. Enter 21; press RETURN.
4. When the I/O light goes out, execute the program.

MANUAL LOADING FROM THE KEYBOARD

1. Insert the program tape.
2. Enter FIND 22; press RETURN.
3. Enter OLD; press RETURN.
4. When the I/O light goes out, execute the program.

PROGRAM EXECUTION

1. Press ENTER DATA (key No. 1). ENTER THE NUMBER OF ROWS AND COLUMNS OF THE TABLE is displayed. Enter the number of rows, a comma, and the number of columns. Press RETURN.

2. ENTER THE NUMBER OF OBSERVATIONS FOR EACH CELL is displayed, and FOR ROW i, COLUMN j appears on the screen. Enter the observation and press RETURN for each cell entry.

3. The entry procedure continues until ENTRY OF TABLE COMPLETE is displayed to indicate that all data has been entered.

NOTE

If errors which cannot be corrected with the CLEAR key are made during data entry, continue to enter the data. After all data has been entered, use CORRECT DATA (key No. 2) to change the incorrect values.

R BY C CONTINGENCY TABLED

CORRECT DATA (Key No. 2)

Key No. 2 allows correction of incorrectly entered values, but must not be used until the table has been filled. To correct an entry in the table:

1. Press CORRECT DATA.
   CORRECT THE TABLE: ENTER ROW AND COLUMN OF CELL
   ROW, COLUMN is displayed.

2. Enter the incorrect row number, a comma, and the incorrect column number. Press RETURN.

3. The value of the existing cell entry is shown and ENTER NEW VALUE is displayed.

4. Enter the correct value and press RETURN.

This correction procedure continues until another function key is pressed. When all cell values are correct, function keys 3, 4, 5, 6, and 7 may be used to perform analysis of the table.

DISPLAY DATA, ROW and COLUMN STATISTICS, EXPECTED VALUES, and TESTS function key usage is demonstrated in the examples which follow.

EXAMPLE 1

Calculate the chi-square test for the following table:

	Column 1	Column 2	Column 3
Row 1	4	5	6
Row 2	7	6	9
Row 3	12	13	14

Load the program and press ENTER DATA (key No. 1). All data for row 1 is entered, then the data for row 2, and row 3. In this example, the value for row 2, column 1 should have been 7, but was entered as 15 in order to illustrate the data correction procedure.

The table is entered as shown below.

```
                R x C  Contingency Table Analysis

Enter the number of rows and columns of the table 3,3

Enter the number of observations for each cell
for row 1,  column 1:  4
for row 1,  column 2:  5
for row 1,  column 3:  6
for row 2,  column 1:  15
for row 2,  column 2:  6
for row 2,  column 3:  9
for row 3,  column 1:  12
for row 3,  column 2:  13
for row 3,  column 3:  14

Entry of table complete
```

To correct the entry in row 2 column 1, press CORRECT DATA (key No. 2)

```
Correct the table: Enter row and column of the cell

Row,column 2,1
The existing cell entry is 15
Enter new value 7

Row,column
```

Press DISPLAY DATA (key No. 3) and the data is displayed as follows:

```
                Data Table

Row 1
 4                5                6

Row 2
 7                6                9

Row 3
 12               13               14
```

TABLED VALUES

R BY C CONTINGENCY TABLED

Row statistics are displayed when ROW STATISTICS (key No. 4) is pressed.

Row Statistics

Row	N	P
1	15	0.197368421053
2	22	0.289473684211
3	39	0.513157894737
Total	76	

Column statistics are displayed when COLUMN STATISTICS (key No. 5) is pressed.

Column Statistics

Column	N	P
1	23	0.302631578947
2	24	0.315789473684
3	29	0.381578947368
Total	76	

Press EXPECTED VALUES (key No. 6) and the expected number of observations in each cell is printed.

Expected Values

Row 1		
4.53947368421	4.73684210526	5.72368421053
Row 2		
6.65789473684	6.94736842105	8.39473684211
Row 3		
11.8026315789	12.3157894737	14.8815789474

R BY C CONTINGENCY TABLED

Press TESTS (key No. 7) and the Chi-Square value, degrees of freedom, significance level, and the number of cells with small observed or expected frequencies are printed.

```
                    Tests


Chi Square                      =  0.376011994003
DF                              =  4.
P(Chi-Square,DF)                =  0.98439


Coefficient of Contingency      =  0.0701652957695
# of cells with exp. val. < 5   =  2.
# of cells with exp. val. < 1   =  0.
```

The chi-square test of .376 with significance level .98 indicates that the hypothesis of row and column independence should not be rejected. The table shows that the number of observations in each row increases in relation to column number increase, and that an observation in a given row provides no specific information about column placement of the observation.

EXAMPLE 2

School children were classified according to standard of clothing and according to intelligence. Standards were as follows:

CLOTHING STANDARDS		INTELLIGENCE STANDARDS	
A	very well clad	A	slow and dull
B	well clad	B	dull
C	poor but passable	C	slow but intelligent
D	very poorly clad	D	fairly intelligent
		E	distinctly capable
		F	very able

Results of the classification are shown below:

	INTELLIGENCE					
CLOTHING	A	B	C	D	E	F
A	33	48	113	209	194	39
B	41	100	202	255	138	15
C	39	58	70	61	33	4
D	17	13	22	10	10	1

R BY C CONTINGENCY TABLED

The program was loaded and the data entered in the following manner:

```
                    R x C  Contingency Table Analysis

Enter the number of rows and columns of the table 4,6

Enter the number of observations for each cell
for row 1,  column 1:  33
for row 1,  column 2:  48
for row 1,  column 3:  113
for row 1,  column 4:  209
for row 1,  column 5:  194
for row 1,  column 6:  39
for row 2,  column 1:  41
for row 2,  column 2:  100
for row 2,  column 3:  202
for row 2,  column 4:  255
for row 2,  column 5:  138
for row 2,  column 6:  15
for row 3,  column 1:  39
for row 3,  column 2:  58
for row 3,  column 3:  70
for row 3,  column 4:  61
for row 3,  column 5:  33
for row 3,  column 6:  4
for row 4,  column 1:  17
for row 4,  column 2:  13
for row 4,  column 3:  22
for row 4,  column 4:  10
for row 4,  column 5:  10
for row 4,  column 6:  1

Entry of table complete
```

To display the table, press DISPLAY DATA (key No. 3).

```
                    Data Table

Row 1
 33                  48                  113                 209
 194                 39

Row 2
 41                  100                 202                 255
 138                 15

Row 3
 39                  58                  70                  61
 33                  4

Row 4
 17                  13                  22                  10
 10                  1
```

Press ROW STATISTICS (key No. 4)

Row Statistics

Row	N	P
1	636	0.368695652174
2	751	0.435362318841
3	265	0.153623188406
4	73	0.0423188405797
Total	1725	

COLUMN STATISTICS (key No. 5) produces the result shown below:

Column Statistics

Column	N	P
1	130	0.0753623188406
2	219	0.126956521739
3	407	0.235942028986
4	535	0.310144927536
5	375	0.217391304348
6	59	0.0342028985507
Total	1725	

EXPECTED VALUES (key No. 6) will cause the display of the expected number of observations for each cell.

Expected Values

Row 1			
47.9304347826	80.7443478261	150.059130435	197.252173913
138.260869565	21.7530434783		
Row 2			
56.5971014493	95.3443478261	177.192463768	232.91884058
163.260869565	25.6863768116		
Row 3			
19.9710144928	33.6434782609	62.5246376812	82.1884057971
57.6086956522	9.06376811594		
Row 4			
5.50144927536	9.26782608696	17.2237681159	22.6405797101
15.8695652174	2.4968115942		

R BY C CONTINGENCY TABLED

TESTS (key No. 7) may be used to display the test results which follow:

Tests

Chi Square	=	174.821377787
DF	=	15.
P(Chi-Square,DF)	=	0.00000
Coefficient of Contingency	=	0.303347824145
# of cells with exp. val. < 5	=	1.
# of cells with exp. val. < 1	=	0.

The chi-square test of independence is 174.8 with a significance level less than 10^{-6}, so we reject the hypothesis that clothing standards and intelligence are independent. The row location of an individual provides some information about the individuals column location. Clothing standard A, for example, indicates that the individual is most likely to be in intelligence class D or E. If his clothing standard is D, he is most likely to have intelligence classification A or C.

2 X 2 CONTINGENCY TABLED

DESCRIPTION

This program will analyze a contingency table with 2 rows and 2 columns. The four data points required as input values are used to generate optional output as follows:

1. Data list, expected number of observations, cell probabilities, and table of expected values from observed values; and

2. Chi-square test with and without Yates's correction for continuity, significance level, and Fisher's exact test.

HARDWARE REQUIREMENTS

A Tektronix 4050-Series Graphic System is required.

METHODS

Let N_{ij} $i = 1,2$; $j = 1,2$ be the table entries.

Let $N_{i.} = N_{i1}+N_{i2}$ and

$N_{.j} = N_{1j}+N_{2j}$ be the respective row and column totals, with N the total number of observations.

The expected number in row i, column j is

$$E_{ij} = N_{i.}N_{.j/N}$$

Probabilities are $E_{ij/N}$.

Deviations are $N_{ij}-E_{ij}$.

Let $D = N_{1.}N_{2.}N_{.1}N_{.2}$, and

$V = N_{11}N_{22}-N_{12}N_{21}$.

The chi-square values calculated are:

chi-square uncorrected = $\frac{N V^2}{D}$, and

chi-square corrected = $N(|V|-N/2)^2/D$.

TABLED VALUES

2 X 2 CONTINGENCY TABLED

Fisher's test is a one tail test for positive association in a table. It is the cumulative probability of the observed table and all less likely tables under the assumption of fixed marginal totals.

The chi-square tests are two-tail tests of independence (pp. 571–573, reference 3). Cochran (Reference 1) recommends that the continuity corrected chi-square test be used if total number of observations is at least 40, or if there are at least 20 observations and no cell has an expected frequency less than 5.

Corrected and uncorrected chi-square tests and the Fisher's test are printed so an appropriate choice may be made for any data.

REFERENCES

1. Cochran, W. G., "Some Methods for Strengthening the Common Chi-Square Tests", *Biometrics*, 1954, Vol. 10, pp. 417.

2. Fisher, R. A., *Statistical Methods For Research Workers*, 1946, Edinburgh: Oliver and Boyd.

3. Kendall, M. G., Stuart, A., *The Advanced Theory of Statistics*, Vol 2, New York: Hafner, 1973.

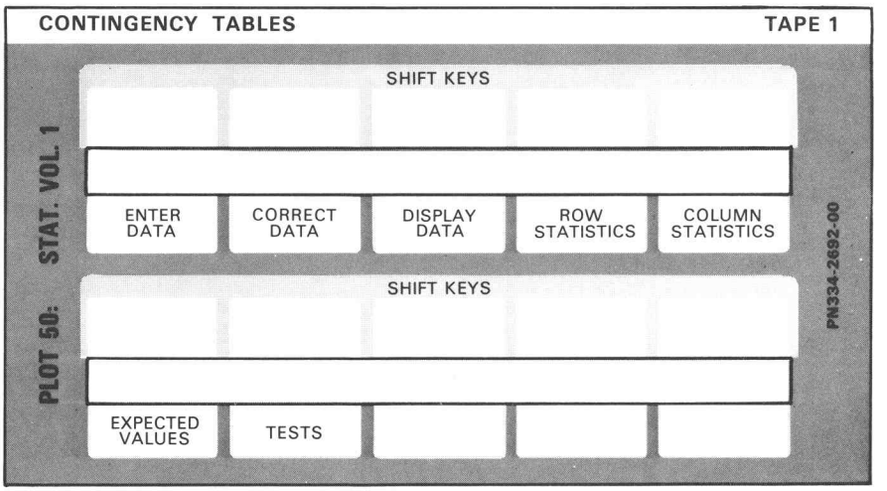
VARIABLES

VARIABLE	USAGE
A	Scratch variable for chi-square
A1	Scratch variable for chi-square
A2	Scratch variable for chi-square
A3	Scratch variable for Fishers test
B	Scratch variable for chi-square
B1	Scratch variable for chi-square
B2	Scratch variable for chi-square
C1	Scratch variable for chi-square
C9	Scratch variable for chi-square
D	Data matrix
F	Scratch
F1	Scratch
I	Scratch
K	Scratch

2 X 2 CONTINGENCY TABLED

M	Scratch
N	Scratch
P1	General row index
P2	General Column index
P6	Chi-square value
X	Scratch
X1	Scratch
X2	Scratch
X3	Scratch
Y	Chi-square probability

FUNCTION KEYS



KEY No.	KEY NAME	FUNCTION
1	ENTER DATA	allows data to be entered from the keyboard.
2	CORRECT DATA	permits correction of data
3	DISPLAY DATA	keys 3, 4, 5, and 6 perform identical functions. Pressing any of these keys will cause the data, expected frequencies, row statistics, and column statistics to be displayed.
4	ROW STATISTICS	
5	COLUMN STATISTICS	
6	EXPECTED VALUES	
7	TESTS	displays Chi-square and Fisher's tests.

TABLED VALUES

2 X 2 CONTINGENCY TABLED

PROGRAM LOADING

This program may be loaded automatically from the directory, or manually from the keyboard.

AUTOMATIC LOADING FROM THE DIRECTORY

1. Insert the program tape.
2. Press AUTO LOAD. The program directory will be displayed with the message ENTER THE PROGRAM NUMBER YOU WANT.
3. Enter 22; press RETURN.
4. When the I/O light goes out, execute the program.

MANUAL LOADING FROM THE KEYBOARD

1. Insert the program tape.
2. Enter FIND 23; press RETURN.
3. Enter OLD; press RETURN.
4. When the I/O light goes out, execute the program.

PROGRAM EXECUTION

1. Press the ENTER DATA key. The message FOR ROW 1, COLUMN 1 is displayed.
2. Enter the data value and press RETURN. The display screen will then request the next value.
3. Repeat step 2 until all four entries have been completed and the message ENTRY OF TABLE COMPLETE is displayed.
4. Press key 3, 4, 5, or 6 to display the descriptive statistics. Key No. 7 will cause the chi-square tests and the Fisher's test to be displayed. Data corrections may be accomplished by pressing key No. 2.
5. To re-execute this program with other values, type RUN and repeat the program execution procedure.

2 X 2 CONTINGENCY TABLED

EXAMPLE 1

Perform the chi-square test for independence in the following table:

	Column 1	Column 2
Row 1	2	3
Row 2	5	2

Load the program and press ENTER DATA (key No. 1).

```
                    2 X 2 CONTINGENCY TABLE

ENTER THE NUMBER OF OBSERVATIONS FOR EACH CELL

FOR ROW 1,COLUMN 1:  2
FOR ROW 1,COLUMN 2:  3
FOR ROW 2,COLUMN 1:  4
FOR ROW 2,COLUMN 2:  2

ENTRY OF TABLE COMPLETE
```

In the example, the entry in row 2, column 2 is incorrect. A 4 was entered (instead of 5) to demonstrate the data correction option.

Data correction is accomplished as shown below:

Press CORRECT DATA (key No. 2).

```
TO CORRECT AN ENTRY OF THE TABLE, ENTER ROW
AND COLUMN OF THE CELL.

ROW,COLUMN = 2,1
THE EXISTING CELL ENTRY IS  4

ENTER THE NEW VALUE:  5

ROW,COLUMN =
```

TABLED VALUES

2 X 2 CONTINGENCY TABLED

The display shown below appears when DISPLAY DATA, ROW STATISTICS, COLUMN STATISTICS, or EXPECTED VALUES (keys 3, 4, 5, or 6) are pressed.

```
                DATA TABLE

ROW  1:         2               3               5
ROW  2:         5               2               7
TOTAL :         7               5               12

EXPECTED VALUE TABLE

                2.91666666667   2.08333333333
                4.08333333333   2.91666666667

PROBABILITIES

                0.243055555556  0.173611111111  0.416666666667
                0.340277777778  0.243055555556  0.583333333333
                0.583333333333  0.416666666667  1.0

TABLE OF DEVIATIONS

                -0.916666666667 0.916666666667
                0.916666666667  -0.916666666667
```

Test are displayed as shown here when TESTS (key No. 7) is pressed.

```
        CHI-SQUARE AND FISHER'S TEST

        CHI-SQUARE UNCORRECTED= 1.18530612245
        DEGREES OF FREEDOM=1
        SIGNIFICANCE LEVEL=0.27627744844

        CHI-SQUARE CORRECTED= 0.244897959184
        DEGREES OF FREEDOM=1
        SIGNIFICANCE LEVEL=0.620690717072

        FISHER'S TEST=0.310606060657
```

Both chi-square tests have high significance levels and the hypothesis of independence would not be rejected.

The significance level for the corrected chi-square test is approximately twice that of the Fisher's exact test. This is because the chi-square corrected is a two tail test and the Fisher's is a one tail.

EXAMPLE 2

The following table classifies 42 children by feeding method and dental occlusion:

	Normal Teeth	Mal-occluded
Breast-fed	4	16
Bottle-fed	1	21

Data entry appears as shown.

```
                    2 X 2 CONTINGENCY TABLE

ENTER THE NUMBER OF OBSERVATIONS FOR EACH CELL

FOR ROW 1,COLUMN 1:  4
FOR ROW 1,COLUMN 2:  16
FOR ROW 2,COLUMN 1:  1
FOR ROW 2,COLUMN 2:  21

ENTRY OF TABLE COMPLETE
```

ONE SAMPLE t-TEST

DESCRIPTION

This program performs the one sample t-test of a population mean, determines confidence intervals, and calculates data sample statistics. The mean tested is the hypothesized value for a single sample of data.

Input is single data points which may be entered from the keyboard or from magnetic tape. Keyboard entered data may be stored on the program tape or on data tapes, and data saved on tape may be deleted, corrected, or added to.

Output may be selected from the following options:

1. list of data entered;
2. t-test of the mean equal to a hypothesized value;
3. confidence intervals on the mean for 90°, 95°, and 99° levels of confidence;
4. histogram of data; and
5. descriptive statistics.

Descriptive statistics which may be displayed are:

1. number of observations;
2. sample mean, variance, and standard deviation;
3. standard error of the mean;
4. data minimum, maximum, and range;
5. coefficient of variation;
6. skewness; and
7. kurtosis.

HARDWARE REQUIREMENTS

A Tektronix 4050-Series Graphic System is required.

The number of data points which may be stored internally is dependent upon the memory size of the machine being used. The following table shows the maximum observations permitted in internal storage:

TEST AND REGRESSIONS

ONE SAMPLE t-TEST

MEMORY SIZE	MAXIMUM NUMBER OF OBSERVATIONS
8K	70
16K	400
24K	1400
32K	2400

The number of data points in each file should not exceed the appropriate limitation defined in the previous table.

If machine capability is enhanced through the addition of additional optional memory, variable WO should be reset. This variable establishes the data matrix dimension and is located at line 110 of the file 28 program listing. If the value of WO is altered, data files must be updated to reflect the increased capability.

PROGRAM LIMITS

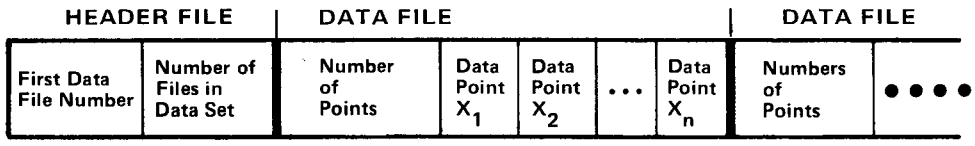
The number of cells specified for histograms should not exceed 20.

TAPE STRUCTURE

All data tapes used by this program must be binary coded, and each must contain a Header File and one or more data files. The Header File, used to load data into memory, includes the file number assigned to the first data file, and the number of files in the data set.

Each data file contains a figure showing the number of data points in the file. This number is followed by data points and calculated data for each point.

The following illustrates the one sample t-test file structure on tape.



ONE SAMPLE t-TEST

METHODS

Formulae used in this program are conventional and are shown in the Appendix.

REFERENCES

1. Dixon, W. J., Massey, F. J., *Introduction to Statistical Analysis*, New York: McGraw-Hill, 1957.

2. Dunn, O. J., Clark, V. A., *Applied Statistics: Analysis of Variance and Regression*, New York: John Wiley and Sons, 1974.

3. Peizer, D. B., Pratt, S. W., "A Normal Approximation for the Binomial, F, Beta, and Other Common Related Tail Probabilities I," *Journal of The American Statistical Association*, 1968.

4. Snedecor, G. W., Cochran, W. G., *Statistical Methods,* sixth edition, Ames, Iowa: Iowa State University Press, 1967.

ONE SAMPLE t-TEST

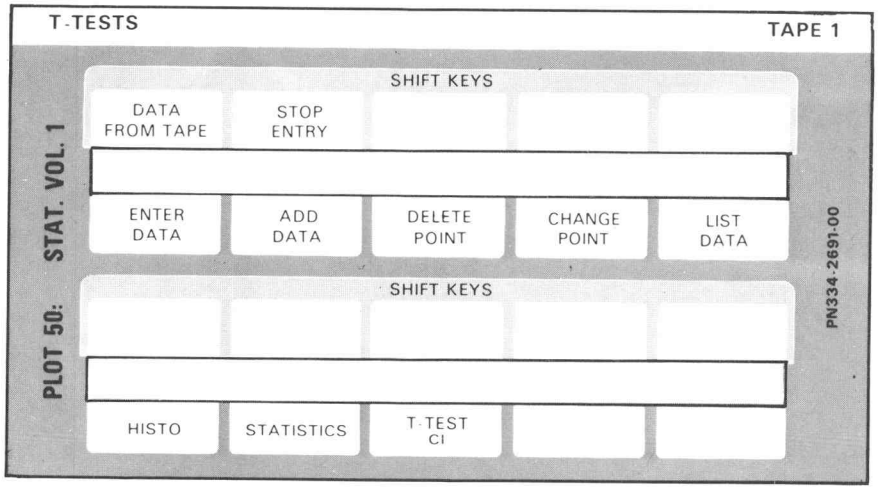
VARIABLES

VARIABLE	USAGE
A	Data matrix
A1	Calculate significance levels
A2	Calculate significance levels
B1	Calculate significance levels
B2	Calculate significance levels
B3	Calculate significance levels
C	Save summary statistics
C1	Maximum for histogram generation
D	Cell width for histogram
D1	Scratch for histogram
D2	Scratch for histogram
D3	Scratch for histogram
D4	Scratch for histogram
D5	Scratch for histogram
D6	Scratch for histogram
D7	Scratch for histogram
E	Matrix for storing histogram data
E1	Flag for saving data on tape 0 = don't save 1 = data on program tape –1 = data on data tape
E2	Flag indicating tape 0 = data tape in 1 = program tape in
E3	File required for overlaying program
E4	Stop entry performed
E5	Program file currently in memory
E8	Overlay key pressed
E$	String variable for entering data
F	Beginning file number and number of files used
I	Scratch
I1	Scratch
J	Scratch
K	Scratch

ONE SAMPLE t-TEST

VARIABLE	USAGE
N	Number of observations in current file
N1	Scratch
N2	Scratch
P	Scratch
Q	Scratch
S	Scratch
T	Scratch
WO	Dimension of A, the data matrix
X	Scratch
X1	Scratch
X2	Scratch
X3	Scratch
X4	Scratch
Y1	Scratch
Y4	Scratch

FUNCTION KEYS



TEST AND REGRESSIONS

ONE SAMPLE t-TEST

KEY No.	KEY NAME	FUNCTION
1	ENTER DATA	allows entry of data from keyboard.
2	ADD DATA	allows data to be added to an existing file.
3	DELETE POINT	permits data point to be deleted from memory and tape.
4	CHANGE POINT	allows data value to be changed.
5	LIST DATA	lists data previously entered.
6	HISTO	causes histogram of data to be displayed.
7	STATISTICS	calculates and displays the number of observations, the sample standard deviation, standard error of the mean, data minimum, data maximum, data range, coefficient of variation, skewness, and kurtosis.
8	T-TEST CI	calculates t-test and confidence intervals for the hypothetical mean.
11	DATA FROM TAPE	allows entry of data from taped file.
12	STOP ENTRY	terminates data entry from keyboard and permits storage of previously entered data.

PROGRAM LOADING

This program may be loaded automatically from the directory, or manually from the keyboard.

AUTOMATIC LOADING FROM THE DIRECTORY

1. Insert the program tape.
2. Press AUTO LOAD. The program directory will be displayed with the message ENTER THE PROGRAM NUMBER YOU WANT.
3. Enter 23; press RETURN.
4. When the I/O light goes out, execute the program.

MANUAL LOADING FROM THE KEYBOARD

1. Insert the program tape.
2. Enter FIND 24; press RETURN.
3. Enter OLD; press RETURN.
4. When the I/O light goes out, execute the program.

PROGRAM EXECUTION

Program execution procedures are determined by the input method and data storage needs. The 5 options from which a selection must be made are as follows:

1. Input data from the program tape;
2. Input data from a previously created data tape;
3. Input from the keyboard, data to be stored on the program tape;
4. Input from the keyboard, data to be stored on a data tape; and
5. Input from the keyboard, no data to be stored on tape.

Execution procedures are described for each option.

OPTION 1, EXECUTION WITH DATA INPUT FROM THE PROGRAM TAPE

Execute the program using a data set previously stored on the program tape.

1. Press DATA FROM TAPE (key No. 11). IS DATA ON PROGRAM TAPE is displayed.
2. Enter YES from the keyboard; press RETURN. When all data from the program tape has been read into memory, the I/O light goes out and ALL DATA ENTERED is displayed.
3. Use the appropriate function keys to execute program operations.

OPTION 2, EXECUTION WITH DATA INPUT FROM DATA TAPE

To execute the program with input from an existing data tape:

1. Press DATA FROM TAPE (key No. 11). IS DATA ON PROGRAM TAPE is displayed.
2. Enter NO from the keyboard; press RETURN. HEADER FILE is displayed.
3. Enter the numeric designation of the header file. Press RETURN. The alarm bell sounds and INSERT DATA TAPE, PRESS RETURN is displayed.
4. Insert the correct data tape and press RETURN. When the data transfer is complete, the I/O light goes out and ALL DATA ENTERED is displayed.
5. Use the appropriate function keys to execute program operations.

OPTION 3, EXECUTION WITH KEYBOARD INPUT, DATA TO BE STORED ON PROGRAM TAPE

To execute the program and store keyboard entered data on the program tape:

1. Press the ENTER DATA (key No. 1). DO YOU WISH TO STORE DATA ON TAPE is displayed.

ONE SAMPLE t-TEST

2. Enter YES from the keyboard; press RETURN. DO YOU WISH TO STORE DATA ON PROGRAM TAPE is displayed.
3. Enter YES from the keyboard and press RETURN.
   ENTER DATA
   X = is displayed.
4. Enter the value of X and press RETURN for each data point.
5. When all data has been entered, use the appropriate function keys to perform other program operations. Data storage will be automatic.
6. If no analysis is desired, press the STOP ENTRY (key No. 12) to store the data and update the Header File.

OPTION 4, EXECUTION WITH KEYBOARD INPUT, DATA TO BE STORED ON A DATA TAPE

To execute the program and store keyboard entered data on a data tape, follow the steps below:

1. Press the ENTER DATA (key No. 1). DO YOU WISH TO STORE DATA ON TAPE is displayed.
2. Enter YES from the keyboard and press RETURN. DO YOU WISH TO STORE DATA ON PROGRAM TAPE is displayed.
3. Enter NO from the keyboard and press RETURN. HEADER FILE is displayed.
4. Enter the number of the header file and press RETURN. INSERT DATA TAPE, PRESS RETURN is displayed and the alarm bell sounds.
5. Insert the correct data tape and press RETURN.
   ENTER DATA
   X = is displayed.
6. Enter the X value and press RETURN for each data point.
7. When all data points have been entered, use the appropriate function keys to perform program operations. Data storage will be automatic.
8. If no data analysis is desired, press the STOP ENTRY (key No. 12) to store the data and update the Header File.

OPTION 5, EXECUTION WITH KEYBOARD INPUT AND NO DATA STORAGE

To execute the program without storing data for later use, proceed as follows:

1. Press ENTER DATA (key No. 1). DO YOU WISH TO STORE DATA ON TAPE is displayed.
2. Enter NO from the keyboard and press RETURN.

   ENTER DATA
   X = is displayed.
3. Enter the X value and press RETURN for each data point.
4. When all data points have been entered, use the function keys to perform any of the operations described on the next pages.

PROGRAM OPERATIONS

Upon completion of the initial data entries, operations are performed with the one sample t-test function keys. The operations described here may be performed in any sequence.

ADD DATA

ADD DATA (key No. 2) will permit addition of new data to the file currently in memory. If the file also resides on tape, the alarm bell sounds to indicate that the tape should be inserted. A message on the screen will identify the kind of tape required; program tape or data tape.

When the tape has been inserted, press RETURN.

ENTER DATA
X = will be displayed, and values may be entered. The RETURN key must be pressed after each value has been keyed.

Other operations may now be performed, or the STOP ENTRY (key No. 12) may be used to update the file.

DELETE POINT

DELETE POINT (key No. 3) allows a value to be deleted from an existing file. The data point will be deleted from internal storage and from the tape file. All subsequent calculations will exclude the deleted point.

If the alarm bell sounds when DELETE POINT is pressed, insert the tape indicated by the message on the screen, and press RETURN.

When DELETE VALUE appears on the screen, enter the value to be deleted and press RETURN. The deletion will be completed with no further message. If the value entered is not in the stored data, DATA NOT FOUND is displayed and no deletion occurs.

ONE SAMPLE t-TEST

CHANGE POINT

Incorrect data points are corrected with CHANGE POINT (key No. 4). When the key is pressed, the alarm bell and a message on the screen indicate any tape requirement. If the proper tape has been inserted, the screen will display CHANGE: INCORRECT VALUE, CORRECT VALUE. When the incorrect value, a comma, and the correct value are entered and the RETURN key is pressed, correction will occur immediately.

If the value specified is not in the data file, DATA NOT FOUND will appear on the screen.

LIST DATA

To list data previously stored, press LIST DATA (key No. 5). If a tape insertion is needed, the alarm bell will sound and a message will be displayed. Insert the correct tape and press RETURN.

DATA IS NOT AVAILABLE TO BE LISTED will be displayed if the data is not stored. Otherwise, the data will be listed on the screen.

If the screen becomes full, the listing will be continued by pressing the PAGE key.

HISTO

Stored data points are used to generate the histogram displayed by pressing HISTO (key No. 6). The alarm bell and a displayed message indicate any necessary magnetic tape insertion. RETURN must be pressed after the correct tape has been inserted.

When HISTO (key No. 6) is pressed, the data minimum, maximum, and range are displayed with the following message:

```
SELECT OPTION
   1   SPECIFY #OF CELLS
   2   SPECIFY CELL WIDTH
   3   SPECIFY OFFSET AND CELL WIDTH
       ENTER OPTION
```

After entering the option number, press RETURN. The screen will then display either # OF CELLS; CELL WIDTH; or OFFSET, CELL WIDTH. Enter the correct information and press RETURN.

The number of cells for option 1 must not exceed 20.

DO YOU WANT NORMAL CURVE will now be displayed. If YES is entered, a normal curve overlay will appear in addition to the histogram. If NO is entered, the histogram will be drawn without the curve.

STATISTICS

Descriptive statistics are displayed when STATISTICS (key No. 7) is pressed. Any required tape insertion is indicated by the alarm bell and a message on the display screen.

Statistics displayed are:

- Number of observations;
- Sample mean, variance, and standard deviation;
- Standard error of the mean;
- Data minimum, maximum, and range;
- Coefficient of variation;
- Skewness; and
- Kurtosis.

t-TEST AND CONFIDENCE INTERVAL

t-TEST CI (key No. 8) initiates the calculation and printing of the hypothesized mean t-test and confidence intervals. If the alarm bell sounds when the key is pressed, insert the tape indicated by the display screen. When the RETURN key is then pressed, the display will be HYPOTHESIZED MEAN.

After the hypothesized mean is entered and the RETURN key is pressed, the t-test and confidence intervals are displayed.

STOP ENTRY

STOP ENTRY (key No. 12) is only used if data has been entered and saved on tape and if no other analysis has been done. This key will ensure that all data is saved on tape.

EXAMPLE 1

Test the hypothesis that the data below is a sample from a population with mean greater than or equal to 29.

27.2, 34.1, 33.9, 28.6, 29.2, 30.1, 31.2, 30.5, 33.6, 30.9, 31.3, 31.0, 32.3, 31.5, 26.2, 29.9, 34.0, 32.1, and 30.7.

ONE SAMPLE t-TEST

Load the program and begin program execution by pressing ENTER DATA (key No. 1). With so few observations, all data may be stored internally and there is no need to store data on tape.

```
                    ONE SAMPLE T-TEST

DO YOU WISH TO STORE DATA ON TAPE? NO
```

Data entry is shown below.

```
ENTER DATA
X = 27.2
X = 34.1
X = 33.9
X = 28.6
X = 29.2
X = 30.1
X = 31.2
X = 30.5
X = 33.6
X = 30.9
X = 31.3
X = 31.0
X = 31.5
X = 26.2
X = 29.9
X = 34.0
X = 32.1
X = 30.7
X =
```

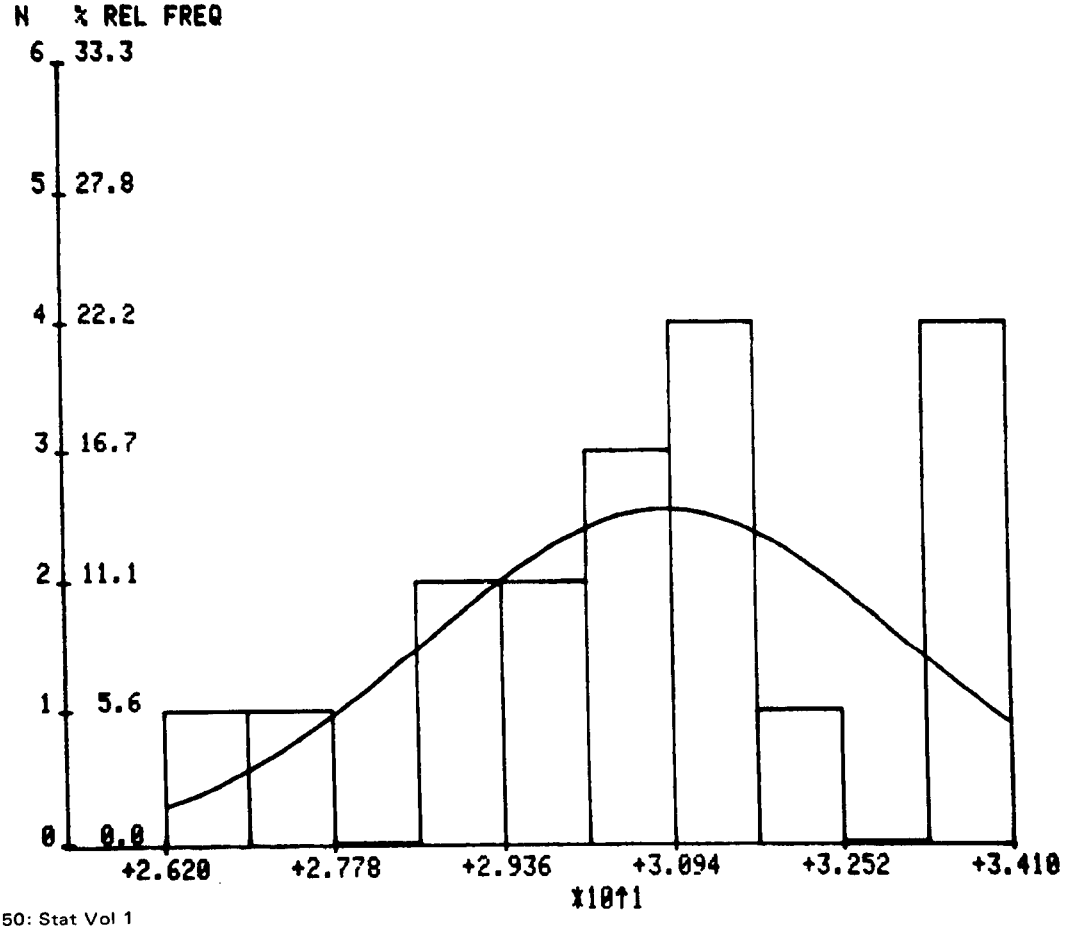
Press LIST DATA (key No. 5)

```
                DATA
27.2000      34.1000      33.9000      28.6000      29.2000
30.1000      31.2000      30.5000      33.6000      30.9000
31.3000      31.0000      31.5000      26.2000      29.9000
34.0000      32.1000      30.7000
```

Press HISTOGRAM (key No. 6)

```
                    HISTOGRAM

DATA MIN = 26.2
DATA MAX = 34.1
DATA RANGE = 7.9


SELECT OPTION
  1  SPECIFY  # OF CELLS
  2  SPECIFY CELL WIDTH
  3  SPECIFY OFFSET AND CELL WIDTH

     ENTER OPTION1
# OF CELLS 10

DO YOU WANT NORMAL CURVE YES
```

To specify the number of cells, enter 1, and press RETURN. In the example above, 10 cells and a normal overlay were specified.



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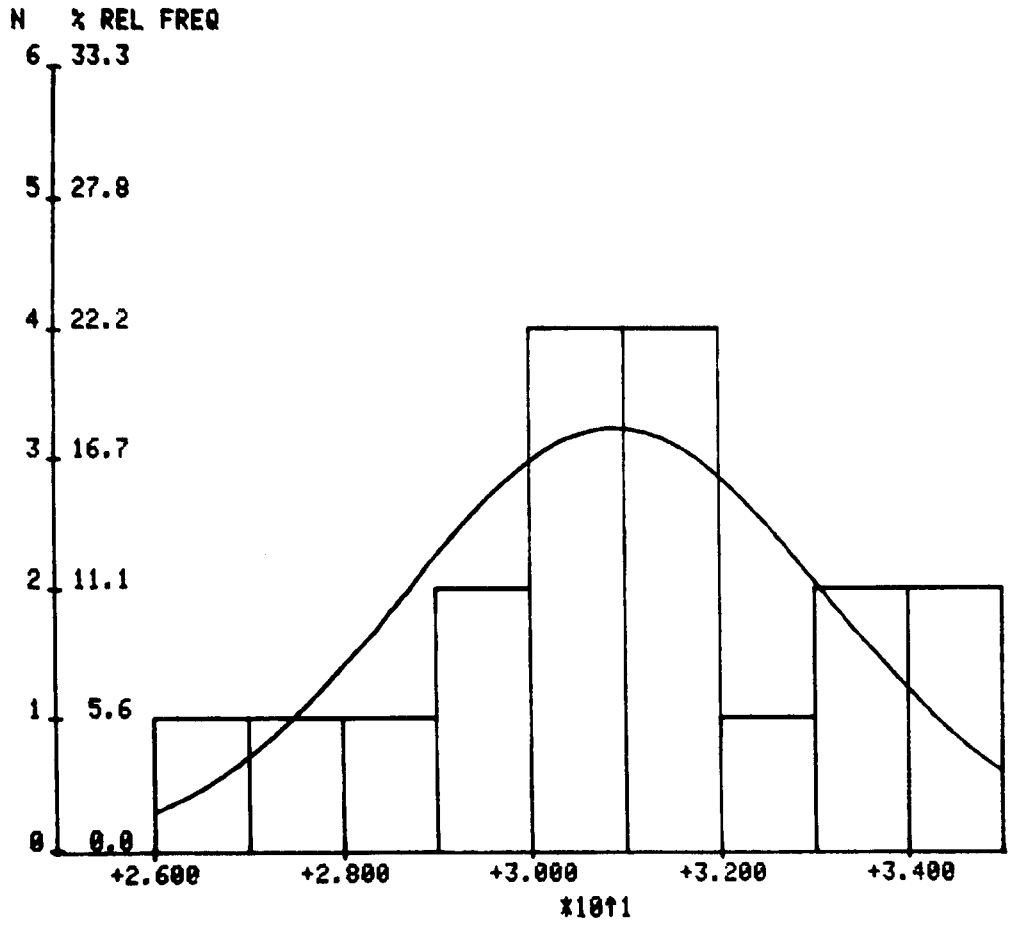
ONE SAMPLE t-TEST

Because the cell limits are confusing, a better histogram might be generated by setting the offset at 26.0 and the cell width at 1. This will produce fewer than 20 cells and clear cell limits.

```
                    HISTOGRAM

DATA MIN = 26.2
DATA MAX = 34.1
DATA RANGE = 7.9

SELECT OPTION
  1  SPECIFY  # OF CELLS
  2  SPECIFY CELL WIDTH
  3  SPECIFY OFFSET AND CELL WIDTH

     ENTER OPTION3
OFFSET, CELL WIDTH 26,1

DO YOU WANT NORMAL CURVE YES
```



ONE SAMPLE t-TEST

When STATISTICS (key No. 7) is pressed, the following display appears:

```
DESCRIPTIVE STATISTICS
N =                    18
MEAN =                 30.8888888889
VARIANCE =             4.94104575165
STD DEV =              2.2228463176
DATA MIN =             26.2
DATA MAX =             34.1
DATA RANGE =           7.9
  STANDARD
ERR OF MEAN =          0.523929901569
 COEFFICIENT
OF VARIATION =         7.19626505697
SKEWNESS =             -0.325494061927
KURTOSIS =             2.66356133199
```

T-TEST (key No. 8) initiates a request for the hypothesised mean.

```
                    T-TEST
HYPOTHESISED MEAN =29
T TEST OF MEAN = 29 IS  3.60523208015
   WITH 17  DEGREES OF FREEDOM

SIGNIFICANCE LEVELS :
                  ONE TAIL TEST =0.00148
                  TWO TAIL TEST =0.00296

SAMPLE MEAN =30.8888888889

CONFIDENCE INTERVALS FOR POPULATION MEAN :
                 LEVEL    LOWER LIMIT     UPPER LIMIT
                 90%  (29.9772421149 , 31.8005356628)
                 95%  (29.7832214569 , 31.9945563209)
                 99%  (29.3701316463 , 32.4076461315)
```

ONE SAMPLE t-TEST

Because the sample mean is 30.9 and the significance level for a one tail test is .0007, we reject the hypothesis that the mean is less than or equal to 29. The hypothesis that the mean is greater than or equal to 29 is accepted.

If the test had been two tailed, we would have rejected the hypothesis that the mean is equal to 29 at the .0014 significance level.

TWO SAMPLE t-TEST

DESCRIPTION

This program tests the hypothesis that the means of two populations are equal. Data samples from the populations may be entered from the keyboard or from magnetic tape, and the input may be corrected, deleted, or updated.

Output may be selected from the following options:

1. data list;
2. number of observations, mean, standard deviation and error of the mean, data minimum, maximum and range, skewness, and kurtosis;
3. pooled variances;
4. t-test of equality of the means;
5. histogram for either or both samples;
6. confidence intervals for each sample mean, and for the difference of the means.

HARDWARE REQUIREMENTS

A Tektronix 4050-Series Graphic System is required. If the Data Communications Interface (Option 1) is installed, minimum acceptable memory configuration is 24K bytes.

The maximum number of data observations which may be stored is dependent upon the memory size of the machine being used. Capabilities are:

Memory Size	Maximum Number of Observations
8K	70
16K	70
24K	600
32K	1600

WO, the variable located in line 110 of program file 34, is set to the correct value of the maximum number of observations. If memory size is increased by the addition of optional memory modules, this variable must be corrected to conform to the table shown above. Because the allowable number of observations per file is determined by the storage capability of the machine, this change will also necessitate data file updating.

TEST AND REGRESSIONS

TWO SAMPLE t-TEST

TAPE STRUCTURE

This program recognizes two types of taped files, both of which must be in binary format.

The Header File consists of two numbers; the Header File designation number, and the number of files used for data storage. Header File information is required for loading data into memory.

Data Files each contain four types of information in the order specified below:

1. The number of observations (N_1) from the first population sample;
2. The number of observations (N_2) from the second population sample;
3. Observation data from the first population; and
4. Observation data from the second population.

The size of each Data File may be stated as N_1+N_2+2.

METHODS

All input data entered from the keyboard is saved in the one dimensional array A. When the number of observations in A is equal to the value of WO, the entire array is either written to tape or erased from memory, depending upon the alternative selected during program execution.

The standard formulae used in this program are contained in the Appendix.

REFERENCES

1. Dixon, W. J., Massey, F. J., *Introduction To Statistical Analysis*, New York: McGraw-Hill, 1957.

2. Dunn, O. J., Clark, V. A., *Applied Statistics: Analysis of Variance and Regression*, New York: John Wiley and Sons, 1974.

3. Peizer, D. B., Pratt, J. W., "A Normal Approximation for the Binomial, F, Beta, and Other Common Related Tail Probabilities I", *Journal of the American Statistical Association*, 63, 1968.

4. Snedecor, G. W., Cochran, W. G., *Statistical Methods, Sixth Edition*, Ames Iowa: Iowa State University Press, 1967.

VARIABLES

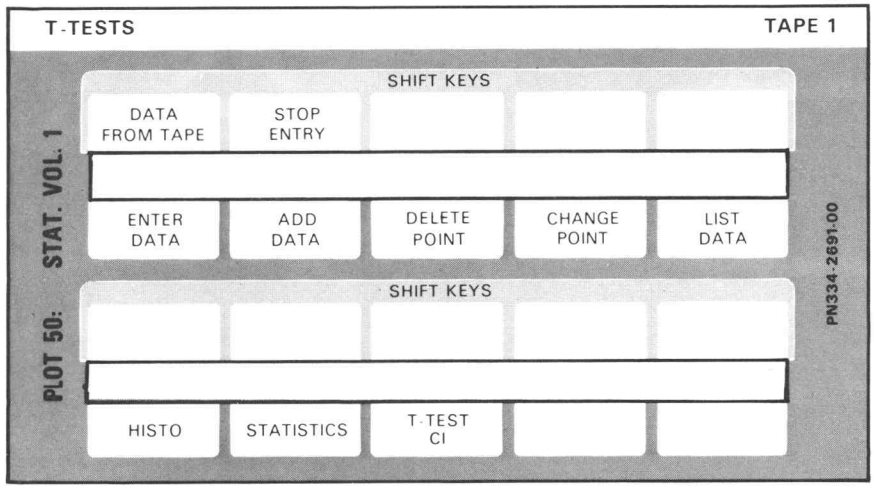
VARIABLE	USAGE
A	Data matrix
A1	Scratch
A2	Scratch
B1	Scratch
B2	Scratch
B3	Scratch
C	Save summary statistics
D	Cell width for histograms
D1	Scratch
D2	Scratch
D3	Scratch
D4	Scratch
D5	Scratch
D6	Scratch
D7	Scratch
E$	String variable for alpha information
E	Matrix for storing histogram data
E1	Flag for saving data on tape 0 = do not save 1 = save on data tape −1 = save on separate tape
E2	Flag for tape type 0 = data tape in 1 = program tape in
E3	File required for overlaying program
E4	Flag for step entry 0 = not performed 1 = step entry performed
E5	program file currently in memory
E8	overlay key pressed
F	Beginning file number, number of files used
I	Scratch
I1	Scratch
J	Scratch
K	Scratch
M$	String variable for input alpha information
N	Number of observations in the current file
N1	Scratch
N2	Scratch

TEST AND REGRESSIONS

TWO SAMPLE t-TEST

VARIABLE	USAGE
P	Scratch
Q	Scratch
S	Scratch
T	Scratch
T1	Scratch
T2	Scratch
WO	Dimension of the data matrix
X	Scratch
X1	Scratch
X2	Scratch
X3	Scratch
X4	Scratch
Y1	Scratch
Y2	Scratch
Y3	Scratch
Y4	Scratch

FUNCTION KEYS



TWO SAMPLE t-TEST

KEY No.	KEY NAME	FUNCTION
1	ENTER DATA	allows entry of data from keyboard.
2	ADD DATA	permits data to be added to an existing file.
3	DELETE POINT	allows data point to be deleted from memory and tape.
4	CHANGE POINT	allows data value to be changed.
5	LIST DATA	lists data previously entered.
6	HISTO	causes histogram of data to be displayed.
7	STATISTICS	calculates and displays the number of observations, the sample mean, sample variance, sample standard deviation, standard error of the mean, data minimum, data maximum, data range, coefficient of variation, skewness, and kurtosis.
8	T-TEST CI	calculates t-test and confidence intervals for the hypothetical mean.
11	DATA FROM TAPE	allows entry of data from tape.
12	STOP ENTRY	terminates data entry from keyboard and permits storage of data, if tape storage option was elected.

PROGRAM LOADING

This program may be loaded automatically from the directory, or manually from the keyboard.

AUTOMATIC LOADING FROM THE DIRECTORY

1. Insert the program tape.
2. Press AUTO LOAD. The program directory will be displayed with the message ENTER THE PROGRAM NUMBER YOU WANT.
3. Enter 24, press RETURN.
4. When the I/O light goes out, execute the program.

MANUAL LOADING FROM THE KEYBOARD

1. Insert the program tape.
2. Enter FIND 25; press RETURN.
3. Enter OLD; press RETURN.
4. When the I/O light goes out, execute the program.

TWO SAMPLE t-TEST

PROGRAM EXECUTION

If input data is to be entered from an existing magnetic tape file, follow the instructions concerning the DATA FROM TAPE (key No. 11). Otherwise, data must be entered from the keyboard with the ENTER DATA (key No. 1).

ENTER DATA

1. Press ENTER DATA (key No. 1) to display DO YOU WISH TO STORE DATA ON TAPE? Reply YES or NO through the keyboard and press RETURN. If you replied NO, omit steps 2, 3, and 4; go to step number 5 below. If you replied YES, continue the sequence.

2. DO YOU WISH TO STORE DATA ON PROGRAM TAPE? is displayed. If the file is on the program tape, type YES; press RETURN, and go to step 4. If the data is on a separate data tape, reply NO and press RETURN.

3. To establish the identity of the input data file, the message HEADER FILE # is displayed. Enter the correct Header File number and press RETURN.

4. If the alarm bell sounds, insert the tape indicated by the message on the screen and press RETURN.

5. The display screen shows:

   ENTER DATA

   X SAMPLE

   Enter the X value and press RETURN. Repeat this step for each value in the first sample. To proceed to data entry for the second sample, press RETURN without entering a data value.

6. The message

   Y SAMPLE

   will be displayed. Enter the Y values and press RETURN after each entry. When all Y values have been entered, use the function keys to execute data analysis.

DATA FROM TAPE

1. To allow entry of data from a previously created magnetic tape file, press DATA FROM TAPE (key No. 11).

NOTE

Data tapes used by this program must conform to the tape standards explained in the TAPE STRUCTURE section.

If the program tape has been removed from the machine, the message INSERT PROGRAM TAPE, PRESS RETURN will be displayed.

2. When the program tape is properly inserted, the message IS DATA STORED ON PROGRAM TAPE will appear. Type YES or NO and press RETURN. If your reply was YES, steps 3 and 4 below do not apply.

3. Because the input data file is not on the program tape, the message INSERT DATA TAPE, PRESS RETURN will be displayed.

4. When the data tape has been inserted, HEADER FILE # will appear on the screen. Enter the Header File number and press RETURN.

5. Data from the tape will be automatically entered and processed until the ALL DATA ENTERED message is displayed. If additional data is to be entered, follow the instructions describing the ADD DATA key function. Otherwise, any of the function keys may be used to analyze the data.

ADD DATA

ADD DATA (key No. 2) allows data to be added to previously entered files. If the original entry was from the keyboard and was saved on tape, the added data will also be saved on tape. If the original data came from a tape file, the added data will always be appended.

1. Press ADD DATA. If the alarm bell sounds, a message on the display screen will indicate that a magnetic tape must be inserted. Insert the correct tape and press RETURN.

2. ADD DATA TO SAMPLE will be displayed. Enter X or Y and press RETURN.

3. To add data to sample X, follow the instructions beginning with step 5 of the ENTER DATA key description. For sample Y, begin with step 6.

4. When the added data points have been entered, they will be included in all further analyses.

DELETE POINT

DELETE POINT (key No. 3) is used to remove single observations from either sample. The deletion will eliminate the observation from internal storage, the tape file, and calculations.

1. Press DELETE POINT (key No. 3). If the alarm bell sounds, insert the magnetic tape indicated by the message on the screen; press RETURN.

TWO SAMPLE t-TEST

2. When the correct tape has been inserted, the following message will be displayed: FROM SAMPLE. Enter X or Y; press RETURN. Enter the value to be deleted; press RETURN.

3. The sample is searched and the observation is deleted from files and calculations. The message CORRECTION DONE indicates completion of the operation. If the data point is not within the designated sample, DATA NOT FOUND is displayed and no deletion occurs.

CHANGE POINT

CHANGE POINT (key No. 4) permits an incorrectly entered observation to be changed in all calculations. If the data is in storage, the stored data will also be corrected.

1. Press CHANGE POINT. If the alarm bell sounds, go to step 2 below. If the bell does not sound, go directly to step 3.

2. Insert the correct tape indicated by the message on the screen; press RETURN. If the alarm bell sounds again, repeat this procedure.

3. The message IN SAMPLE is displayed. Enter X or Y, and press RETURN. Enter the incorrect value and the correct value, using a comma as a delimiter between the two values. Press RETURN.

4. The sample specified is searched for the incorrect value, and corrections are made in storage and in calculations. CORRECTION DONE is displayed to indicate completion. DATA NOT FOUND indicates that the value designated as incorrect was not found.

5. When this operation has been completed, other function keys may be used for analysis of the corrected data.

LIST DATA

When LIST DATA (key No. 5) is pressed, both data samples are listed on the screen. If a tape insertion is required, the alarm bell and the display screen will indicate the correct tape. If all data has not been stored, the message DATA IS NOT AVAILABLE TO BE LISTED will appear.

HISTO

1. Press HISTO (key No. 6).If the alarm sounds, the message displayed will indicate a tape insertion requirement. Insert the tape and press RETURN. If the alarm sounds again, repeat this procedure.

2. If the input data has not been stored, the following message will appear: HISTOGRAM MAY NOT BE CALCULATED. Otherwise, the message HISTOGRAM FOR SAMPLE will be displayed. Enter X or Y and press RETURN.

3. The data minimum, maximum, and range for the selected sample are displayed with the following message:

```
S E L E C T   O P T I O N
    1    S P E C I F Y   # O F   C E L L S
    2    S P E C I F Y   C E L L   W I D T H
    3    S P E C I F Y   O F F S E T   A N D   C E L L   W I D T H
         E N T E R   O P T I O N
```

4. After entering the option number, press RETURN. The screen will then display either # OF CELLS; CELL WIDTH; or OFFSET, CELL WIDTH. Enter the appropriate information and press RETURN. Remember, the number of cells for option 1 must not exceed 20.

5. DO YOU WANT NORMAL CURVE? will now be displayed. If YES is entered, the curve will appear with the histogram when RETURN is pressed. For a NO answer, the histogram is drawn without the curve.

STATISTICS

Descriptive statistics for both samples are displayed when STATISTICS (key No. 7) is pressed. Any required tape insertion is indicated by the alarm bell and a message on the display screen.

Statistics displayed are:

number of observations;
sample mean, variance, and standard deviation;
standard error of the mean;
data minimum, maximum, and range;
coefficient of variation;
skewness; and
kurtosis.

TWO SAMPLE t-TEST

t-TEST AND CONFIDENCE INTERVALS

t-TEST CI (key No. 8) causes calculation and printing of the t-test and confidence intervals for the means. If the alarm bell sounds when the key is pressed, a message on the display screen will indicate that a tape insertion is required. When the RETURN key is pressed, the t-test of equality of the means is calculated and printed with the confidence intervals for the means.

STOP ENTRY

The STOP ENTRY (key No. 12) is used only if data entry is not completed or if no immediate analysis is desired. Use of this key enables keyboard entered data to be stored for later additions or analysis. If the tape data storage option was selected, STOP ENTRY will initiate storage to the tape file.

EXAMPLE 1

In this example, taken from Reference 2, (pages 49-53), IQ scores are obtained from 10 girls whose parents have a high income and from 9 girls whose parents have a low income. The hypothesis states that the two sets of girls have the same mean IQ.

Sample X is high income IQ measurements of 124, 114, 115, 106, 84, 96, 106, 126, 124, and 116. Sample Y, low income IQ data is 113, 97, 108, 95, 105, 69, 113, 98, and 118.

Because of the small sample size, data will not be stored on tape. The program is loaded, and data is entered as shown below:

```
TWO SAMPLE T-TEST
DO YOU WISH TO STORE DATA ON TAPE? NO
```

TWO SAMPLE t-TEST

```
                    ENTER DATA

X SAMPLE
X =124
X =114
X =115
X =106
X =84
X =96
X =106
X =126
X =124
X =116
X =

Y SAMPLE
Y =113
Y =97
Y =108
Y =95
Y =105
Y =69
Y =113
Y =98
Y =118
Y =
```

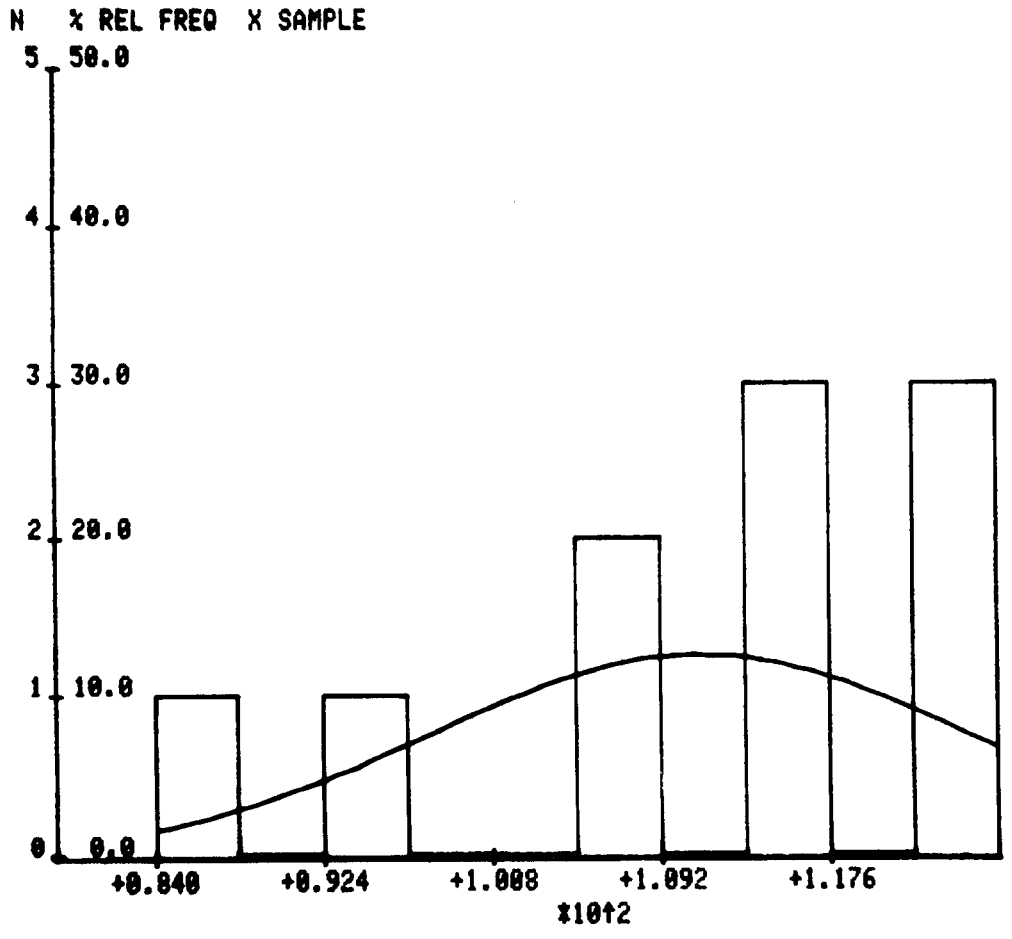
Press LIST DATA (key No. 5).

```
                    DATA

                  X SAMPLE
 124.0000         114.0000        115.0000        106.0000         84.0000
  96.0000         106.0000        126.0000        124.0000        116.0000

                  Y SAMPLE
 113.0000          97.0000        108.0000         95.0000        105.0000
  69.0000         113.0000         98.0000        118.0000
```

TWO SAMPLE t-TEST

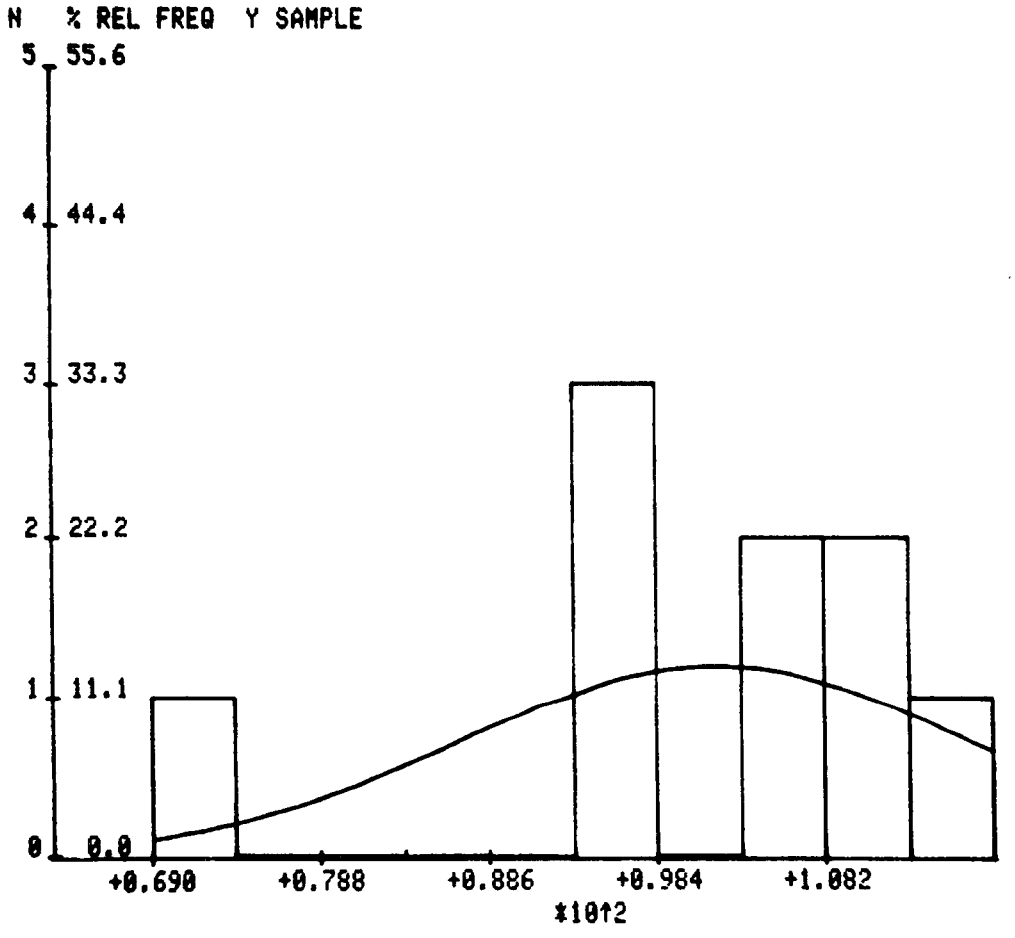
Press HISTO (key No. 6) to display a histogram for both samples. For the X sample, specify 10 cells with a normal curve overlay.

```
                    HISTOGRAM

HISTOGRAM FOR SAMPLE ? X


DATA MIN = 84
DATA MAX = 126
DATA RANGE = 42


SELECT OPTION
  1  SPECIFY  # OF CELLS
  2  SPECIFY CELL WIDTH
  3  SPECIFY OFFSET AND CELL WIDTH

     ENTER OPTION1
# OF CELLS 10

DO YOU WANT NORMAL CURVE YES
```



For the Y sample, again specify 10 cells with a normal curve overlay.

```
                    HISTOGRAM
HISTOGRAM FOR SAMPLE ? Y


DATA MIN = 69
DATA MAX = 110
DATA RANGE = 49


SELECT OPTION
  1  SPECIFY  # OF CELLS
  2  SPECIFY CELL WIDTH
  3  SPECIFY OFFSET AND CELL WIDTH

     ENTER OPTION1
# OF CELLS 10

DO YOU WANT NORMAL CURVE YES
```



TWO SAMPLE t-TEST

```
                    DESCRIPTIVE STATISTICS
                    X SAMPLE        Y SAMPLE

N =                 10              9

MEAN =              111.1           101.777777778

VARIANCE =          179.655555556   215.194444445

STD DEV =           13.4035650316   14.6695073007

DATA MIN =          84              69

DATA MAX =          126             118

DATA RANGE =        42              49

  STANDARD
ERR OF MEAN =       3.3331666625    3.36283243343

 COEFFICIENT
OF VARIATION =      12.0644149699   14.4132713653

SKEWNESS =          -0.768872598457 -1.1894220069

KURTOSIS =          2.67082467084   1748.44015146

                  POOLED VARIANCE =196.379738562


                    T-TEST

T TEST OF EQUALITY OF MEANS =  1.4478233179
   WITH 17  DEGREES OF FREEDOM

SIGNIFICANCE LEVELS :
                    ONE TAIL TEST =0.08936
                    TWO TAIL TEST =0.17872

CONFIDENCE INTERVALS FOR MEANS :

X MEAN  =111.1
                  LEVEL    LOWER LIMIT      UPPER LIMIT
                    90%  (103.328251373 , 118.871748627)
                    95%  (101.509112173 , 120.690887827)
                    99%  (97.322858778 , 124.877141222)

Y MEAN  =101.777777778
                  LEVEL    LOWER LIMIT      UPPER LIMIT
                    90%  (92.6825762195 , 110.872979336)
                    95%  (90.4987615124 , 113.056794043)
                    99%  (85.3679996088 , 118.187555947)

XMEAN - YMEAN  =9.32222222222
                  LEVEL    LOWER LIMIT      UPPER LIMIT
                    90%  (-1.88137014212 , 20.5258145866)
                    95%  (-4.26576772416 , 22.9102121686)
                    99%  (-9.34239386871 , 27.9868383132)
```

TWO SAMPLE t-TEST

The t-test for equality of means is 1.45 with significance level .18. Because of the size of this significance level, we do not reject the hypothesis of equality of the means.

An inspection of the confidence intervals for the difference of the means shows that the confidence intervals contain both positive and negative values, (i.e., zero). The zero value again leads to the conclusion that we cannot reject the hypothesis of equal means.

Although the difference of means, 9.32, is approximately 10% of the sample means, we do not reject equality of the means because of the large variance within the sample. The variance is graphically illustrated by the histograms.

PAIRED t-TEST

DESCRIPTION

This program performs the paired t-test of population means equality for paired sample data. Data pairs may be entered from the keyboard or from magnetic tape files, and data may be corrected, deleted, or updated.

Optional output may be selected from the following:

1. list of data pairs and differences;
2. histogram of either sample data, or of the differences;
3. data statistics including variance, standard deviation, skewness, and kurtosis;
4. t-test of equality of the means;
5. confidence intervals for either sample or for the difference of the means.

HARDWARE REQUIREMENTS

A Tektronix 4050-Series Graphic System is required. If the Data Communications Interface (Option 1) is installed, minimum acceptable memory configuration is 16K bytes.

The number of data pairs which may be stored internally depends upon the available memory size of your machine. The following table shows the maximum number of data pairs permitted in internal storage without program modification .

MEMORY SIZE	MAXIMUM NUMBER OF DATA PAIRS
8K	30
16K	100
24K	300
32K	300

For a 32K machine, up to 800 data pairs may be stored internally by changing the value of variable WO to 800. This variable is located on line 110 of program file 34. If the value of the variable is changed, data files on tape must then be updated to accomodate the change.

PAIRED t-TEST

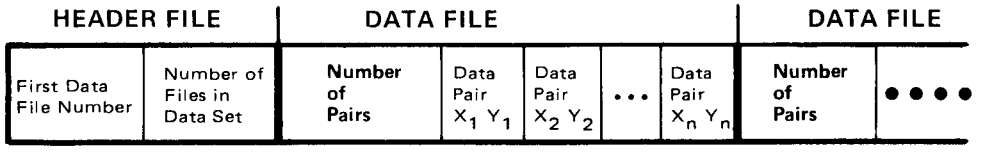
TAPE STRUCTURE

The two types of taped files recognized and created by this program are Header Files and Data Files. Both must be in binary format.

Header Files consist of two numbers; the Header File designation number, and the number of Data Files in the data set.

Data Files each contain two types of information. The number of data observations contained in the file is followed by the data pairs in the form $X_1\ Y_1, X_2 Y_2, \ldots X_n Y_n$.

The paired t-test file structure is illustrated below:



METHODS

The difference (D) of any XY data pair is X-Y. Thus, $D_1 = X_1 - Y_1$, $D_n = X_n - Y_n$, etc.

The paired t-test is the one sample t-test applied to the differences. Standard formulae used to calculate the descriptive statistics are shown in the Appendix.

REFERENCES

1. Dixon, W. J., Massey, F. J., *Introduction To Statistical Analysis*, New York: McGraw-Hill, 1957.

2. Dunn, O. J., Clark, V. A., *Applied Statistics: Analysis of Variance and Regression*, New York: John Wiley and Sons, 1974.

3. Peizer, D. B., Pratt, J. W., "A Normal Approximation for the Binomial, F, Beta, and Other Common Related Tail Probabilities I", *Journal of the American Statistical Association*, 63, 1968.

4. Snedecor, G. W., Cochran, W. G., *Statistical Methods, Sixth Edition*, Ames Iowa: Iowa State University Press, 1967.

PAIRED t-TEST

VARIABLES

VARIABLE	USAGE
A	Data matrix
A1	Scratch
A2	Scratch
B1	Scratch
B2	Scratch
B3	Scratch
C	Save summary statistics
D	Cell width for histograms
D1	Scratch
D2	Scratch
D3	Scratch
D4	Scratch
D5	Scratch
D6	Scratch
D7	Scratch
E$	String variable for alpha information
E	Matrix for storing histogram data
E1	Flag for saving data on tape 0 = do not save 1 = save on data tape −1 = save on separate tape
E2	Flag for tape type 0 = data tape in 1 = program tape in
E3	File required for overlaying program
E4	Flag for step entry 0 = not performed 1 = step entry performed
E5	Program file currently in memory
E8	Overlay key pressed
F	Beginning file number, number of files used
I	Scratch
I1	Scratch
J	Scratch
K	Scratch

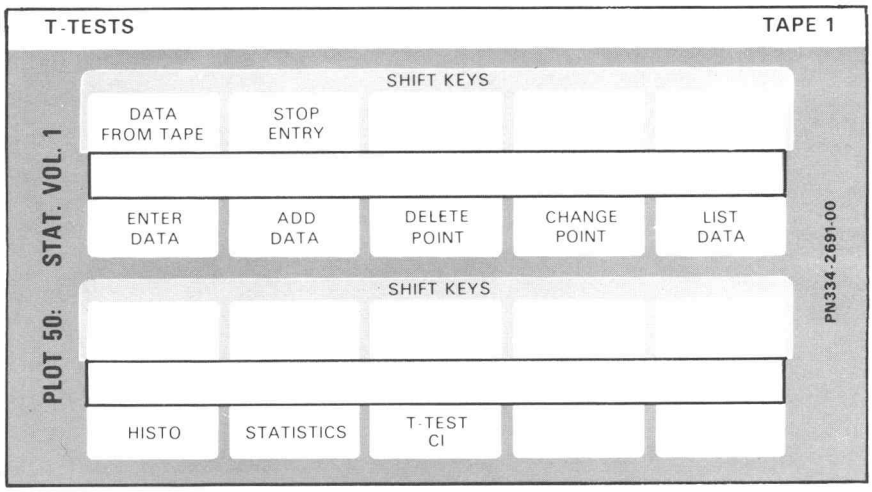
PAIRED t-TEST

VARIABLE	USAGE
N	Number of observations in the current file
P	Scratch
Q	Scratch
S	Scratch
T	Scratch
T1	Scratch
W2	Scratch
W0	Dimension of the data matrix A.
X	Scratch
X1	Scratch
S2	Scratch
X3	Scratch
X4	Scratch
Y1	Scratch
Y2	Scratch
Y3	Scratch
Y4	Scratch

TEST AND REGRESSIONS

PAIRED t-TEST

FUNCTION KEYS



KEY No.	KEY NAME	FUNCTION
1	ENTER DATA	allows entry of data from keyboard.
2	ADD DATA	causes data to be added to an existing file.
3	DELETE POINT	permits data pair to be deleted from memory and tape.
4	CHANGE POINT	allows data value to be changed.
5	LIST DATA	lists data previously entered and data pair differences.
6	HISTO	causes histogram of data to be displayed.
7	STATISTICS	calculates and displays the number of observations, the sample mean, sample variance, sample standard deviation, standard error of the mean, data minimum, data maximum, data range, coefficient of variation, skewness, and kurtosis.
8	T-TEST CI	calculates t-test and confidence intervals for the mean of each sample and for the mean of the differences.
11	DATA FROM TAPE	allows entry of data from taped file.
12	STOP ENTRY	terminates data entry from keyboard and permits storage of data, if tape storage option was elected.

PROGRAM LOADING

This program may be loaded automatically from the directory, or manually from the keyboard.

AUTOMATIC LOADING FROM THE DIRECTORY

1. Insert the program tape.
2. Press AUTO LOAD. The program directory will be displayed with the message ENTER THE PROGRAM NUMBER YOU WANT.
3. Enter 25, press RETURN.
4. When the I/O light goes out, execute the program.

MANUAL LOADING FROM THE KEYBOARD

1. Insert the program tape.
2. Enter FIND 26, press RETURN.
3. Enter OLD; press RETURN.
4. When the I/O light goes out, execute the program.

PROGRAM EXECUTION

If input data is to be entered from an existing magnetic tape file, follow the instructions concerning the DATA FROM TAPE (key No. 11). Otherwise, data must be entered from the keyboard as described below.

ENTER DATA

1. Press ENTER DATA (key No. 1). The screen displays DO YOU WISH TO STORE DATA ON TAPE? Reply YES or NO through the keyboard and press RETURN. If you replied NO, omit steps 2, 3, and 4; go to step number 5 below. If you replied YES, continue the instruction sequence.

2. DO YOU WISH TO STORE DATA ON PROGRAM TAPE? is displayed. If the file is on the program tape, type YES; press RETURN, and go to step 4. If the data is on a separate data tape, reply NO and press RETURN.

3. To establish the identity of the input data file, the message HEADER FILE is displayed. Enter the correct Header File number and press RETURN.

PAIRED t-TEST

4. If the alarm bell sounds, insert the tape indicated by the message on the screen and press RETURN.

5. The display screen shows:

ENTER DATA

X,Y

Enter the X and Y value, and press RETURN. Repeat this step for each pair. When all value pairs have been entered, use the function keys to perform data analysis.

DATA FROM TAPE

1. To allow entry of data pairs from an existing magnetic tape file, press DATA FROM TAPE (key No. 11).

NOTE

Data tapes used by this program must conform to the tape standards explained in the DESCRIPTION section.

If the program tape has been removed from the machine, the message INSERT PROGRAM TAPE, PRESS RETURN will be displayed.

2. When the program tape is properly inserted, the message IS DATA STORED ON PROGRAM TAPE will appear. Type YES or NO and press RETURN. If your reply was YES, steps 3 and 4 below do not apply.

3. Because the input data file is not on the program tape, the message INSERT DATA TAPE, PRESS RETURN will be displayed.

4. When the data tape has been inserted, HEADER FILE will appear on the screen. Enter the Header File number and press RETURN.

5. Data from the taped file will be automatically entered and processed until the ALL DATA ENTERED message is displayed. If additional data is to be entered, follow the instructions describing the ADD DATA key function. Otherwise, any of the function keys may be used to analyze the data.

ADD DATA

ADD DATA (key No. 2) allows data to be added to previously entered files. If the original entry was from the keyboard and was saved on tape, the added data will also be saved on tape. If the original data came from a tape file, the added data will always be appended.

1. Press ADD DATA. If the alarm bell sounds, a message on the display screen will indicate that a magnetic tape must be inserted. Insert the correct tape and press RETURN.

2. ADD DATA X,Y will be displayed. Enter the X,Y pair and press RETURN. Repeat this step for each pair to be added.

3. When all pairs have been added, use the function keys to perform data analysis.

DELETE POINT

DELETE POINT (key No. 3) is used to remove data pairs from internal storage, calculations, and from tape files.

1. Press DELETE POINT. If the alarm bell sounds, insert the magnetic tape indicated by the message on the screen. Press RETURN.

2. When the correct tape has been inserted, the following message will be displayed: DELETE X,Y. Enter the X,Y pair to be deleted and press RETURN.

3. The data pair is deleted from files and calculations. If the message DATA NOT FOUND is displayed, no deletion has occurred.

CHANGE POINT

CHANGE POINT (key No. 4) permits an incorrectly entered pair to be changed in all calculations, storage, and tape files.

1. Press CHANGE POINT. If the alarm sounds, go to step 2 below. If not, omit the next step and go to step 3.

2. Insert the correct tape indicated by the message on the display screen. Press RETURN. Repeat this procedure if the alarm bell rings again.

PAIRED t-TEST

3. CHANGE X,Y TO X,Y is displayed. Enter the incorrect pair followed by the correct pair. Commas may be used as delimiters between the 4 values entered. Press RETURN.

4. The data is searched for the incorrect value, and corrections are made in storage and in calculations. CORRECTION DONE is displayed to indicate completion. DATA NOT FOUND indicates that the value designated as incorrect was not found.

5. When this operation has been completed, other function keys may be used for analysis of the corrected data.

LIST DATA

To list data previously stored internally or on magnetic tape, press LIST DATA (key No. 5). If a tape insertion is required, a reminder message will be displayed and the alarm bell will sound. Insert the correct tape and press RETURN.

If the data has not been stored, DATA NOT AVAILABLE TO BE LISTED will be displayed.

Remember, if the screen becomes full, no more data will be listed until HOME PAGE is pressed.

HISTO

HISTO (key No. 6) generates and displays histograms of X or Y data points, or of the differences. Necessary tape insertions are indicated by the alarm bell and a displayed message. The RETURN key must be pressed after the requested tape has been inserted.

If the data has not been stored, HISTOGRAM MAY NOT BE CALCULATED is displayed. Otherwise, the message HISTOGRAM FOR SAMPLE? is displayed. Enter either X, Y, or D (as in difference) to indicate the data to be used.

The data minimum, maximum, and range will be displayed with the following message

```
SELECT OPTION
   1   SPECIFY #OF CELLS
   2   SPECIFY CELL WIDTH
   3   SPECIFY OFFSET AND CELL WIDTH
       ENTER OPTION
```

After entering the option number, press RETURN. The next message will be # OF CELLS; or CELL WIDTH; or OFFSET, CELL WIDTH. Enter the information requested and press RETURN. If option 1 was selected, the number of cells specified must not exceed 20.

DO YOU WANT NORMAL CURVE will now be displayed. If your reply is YES, a normal curve overlay will appear in addition to the histogram.

STATISTICS

To calculate and display the descriptive statistics for each sample and for the difference, press STATISTICS (key No. 7).

If the alarm bell sounds, insert the tape indicated by the message on the screen and press RETURN.

t-TEST and CONFIDENCE INTERVALS

t-TEST CI (key No. 8) initiates calculation and display of the t-test of the equality of means, and of the confidence intervals. Tape insertion requirements are indicated by the alarm bell and a message on the display screen.

STOP ENTRY

STOP ENTRY (key No. 12) is only used to store data for later analysis or for further entries at some other time. If all data has not been entered or if analysis is not wanted until later, press the STOP ENTRY key to initiate data storage.

EXAMPLES

Two new types of rations are fed to pigs. Which one will produce a higher weight gain?

Two litter mates are selected from 12 litters and one member of each pair is randomly assigned to receive ration A. The other will receive ration B. Weight gains are shown below:

RATION A	30	31	34	29	26	32	31	35	32	38	34	29
RATION B	31	26	24	28	29	30	28	29	32	32	26	29

PAIRED t-TEST

Load the program and press ENTER DATA (key No. 1). Because the number of observations is small (12), we choose to store our data in memory rather than on tape.

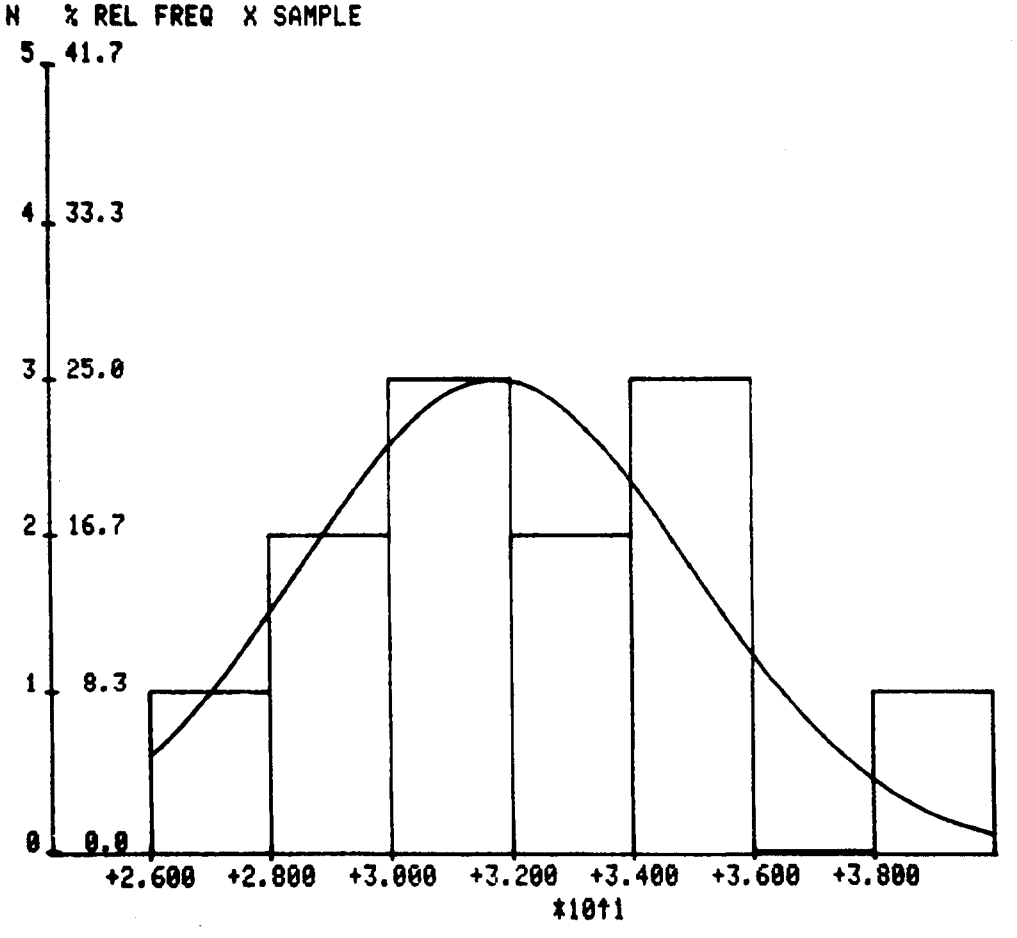
```
                PAIRED SAMPLE T-TEST

DO YOU WISH TO STORE DATA ON TAPE? NO

          ENTER DATA

X , Y =30,31
 DIFFERENCE =-1
X , Y =31,26
 DIFFERENCE =5
X , Y =34,24
 DIFFERENCE =10
X , Y =29,28
 DIFFERENCE =1
X , Y =26,29
 DIFFERENCE =-3
X , Y =32,30
 DIFFERENCE =2
X , Y =31,28
 DIFFERENCE =3
X , Y =35,29
 DIFFERENCE =6
X , Y =32,32
 DIFFERENCE =0
X , Y =38,32
 DIFFERENCE =6
X , Y =34,26
 DIFFERENCE =8
X , Y =29,29
 DIFFERENCE =0
X , Y =
```

LIST DATA (key No. 5) is pressed to display the data and differences.

```
                DATA

      X             Y          DIFFERENCES
 30.0000       31.0000         -1.0000
 31.0000       26.0000          5.0000
 34.0000       24.0000         10.0000
 29.0000       28.0000          1.0000
 26.0000       29.0000         -3.0000
 32.0000       30.0000          2.0000
 31.0000       28.0000          3.0000
 35.0000       29.0000          6.0000
 32.0000       32.0000          0.0000
 38.0000       32.0000          6.0000
 34.0000       26.0000          8.0000
 29.0000       29.0000          0.0000
```

For a histogram of the A ration data, press HISTO (key No. 6) and enter X. The data range is 12 so a cell width of 2 will provide 6 cells. Option 2 allows cell width specification.

```
                    HISTOGRAM

HISTOGRAM FOR SAMPLE ? X


DATA MIN = 26
DATA MAX = 38
DATA RANGE = 12


SELECT OPTION
  1  SPECIFY  # OF CELLS
  2  SPECIFY CELL WIDTH
  3  SPECIFY OFFSET AND CELL WIDTH

     ENTER OPTION2
CELL WIDTH 2

DO YOU WANT NORMAL CURVE YES
```



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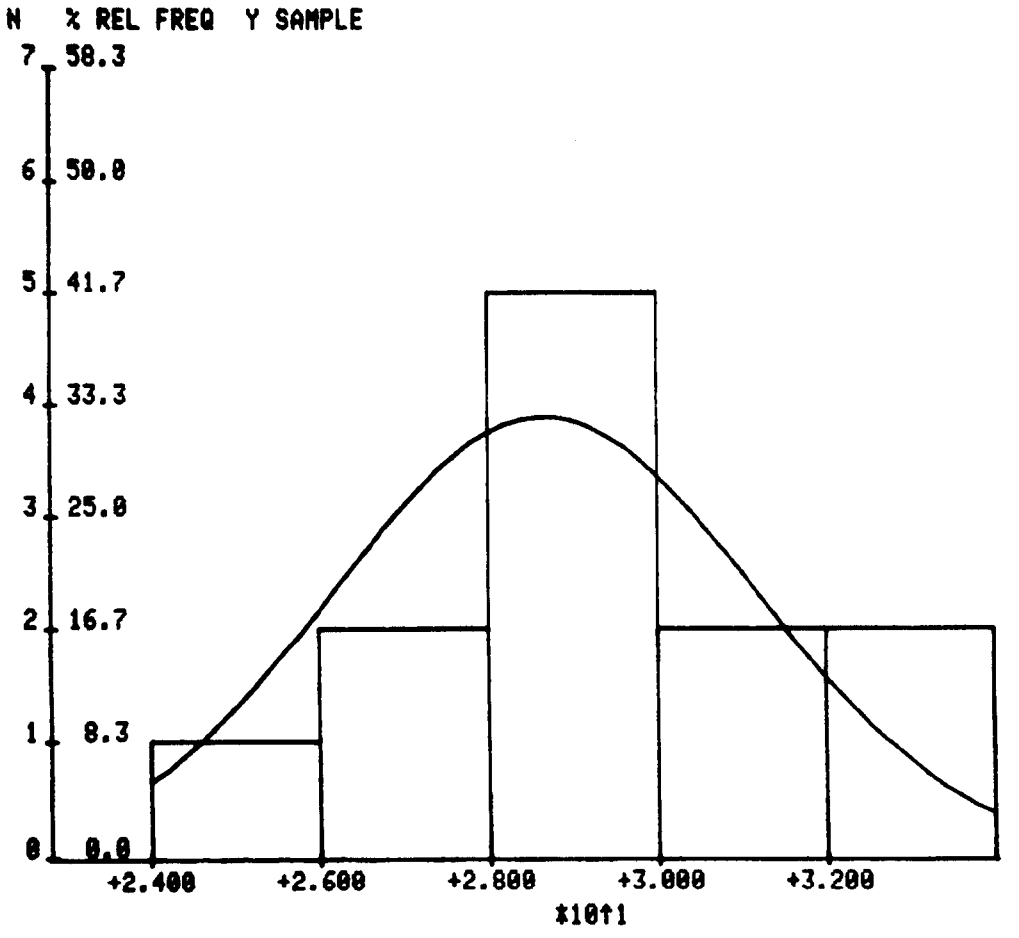
PAIRED t-TEST

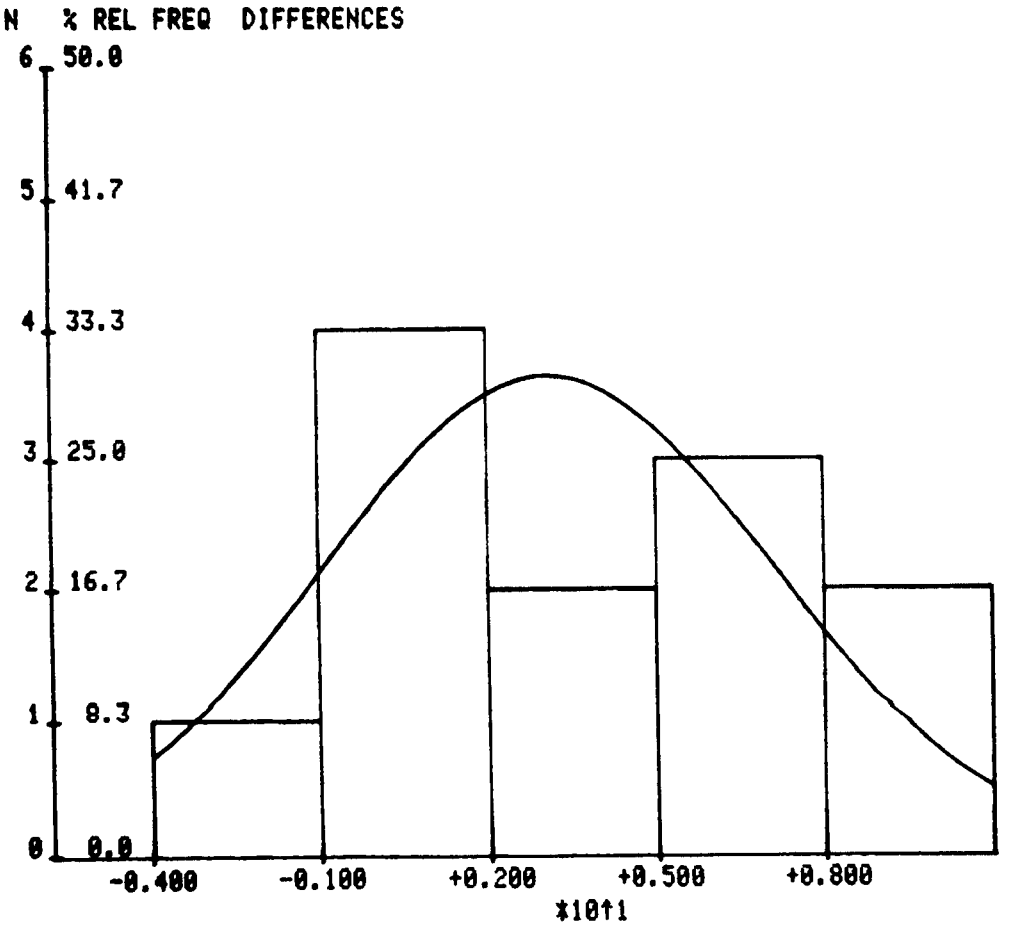
The same procedure is followed for the Y sample (ration B).

```
                                HISTOGRAM

HISTOGRAM FOR SAMPLE ? Y


DATA MIN = 24
DATA MAX = 32
DATA RANGE = 8


SELECT OPTION
  1  SPECIFY  # OF CELLS
  2  SPECIFY CELL WIDTH
  3  SPECIFY OFFSET AND CELL WIDTH

    ENTER OPTION2
CELL WIDTH 2

DO YOU WANT NORMAL CURVE YES
```



To display a histogram of the differences, press HISTO and enter D. In this example, option 3 is chosen with an offset of –4, and cell width of 3.

```
                    HISTOGRAM

HISTOGRAM FOR SAMPLE ? D


DATA MIN = -3
DATA MAX = 10
DATA RANGE = 13


SELECT OPTION
  1  SPECIFY  # OF CELLS
  2  SPECIFY CELL WIDTH
  3  SPECIFY OFFSET AND CELL WIDTH

     ENTER OPTION3
OFFSET, CELL WIDTH -4,3

DO YOU WANT NORMAL CURVE YES
```



PAIRED t-TEST

The STATISTICS (key No. 7) will initiate the display shown below.

DESCRIPTIVE STATISTICS

	X SAMPLE	Y SAMPLE	DIFFERENCES
N =	12		
MEAN =	31.75	28.6666666667	3.08333333333
VARIANCE =	10.2045454545	6.06060606061	15.5378787879
STD DEV =	3.19445542378	2.46182981959	3.94181161243
DATA MIN =	26	24	-3
DATA MAX =	38	32	10
DATA RANGE =	12	8	13
STANDARD ERR OF MEAN =	0.922159849418	0.710663054519	1.13790299777
COEFFICIENT OF VARIATION =	10.0612769253	8.58777844042	127.842538781
SKEWNESS =	0.184598883872	-0.323854905825	0.223651408056
KURTOSIS =	2.7678285326	2.31000000007	2.00453453988

T-TEST

T-TEST OF MEAN DIFFERENCES = 0 IS 2.70966272115
WITH 11 DEGREES OF FREEDOM

SIGNIFICANCE LEVELS :
ONE TAIL TEST =0.00737
TWO TAIL TEST =0.01474

MEAN DIFFERENCE = 3.08333333333

CONFIDENCE INTERVALS FOR MEAN DIFFERENCE :

LEVEL	LOWER LIMIT	UPPER LIMIT
90%	(1.03928848044 ,	5.12737818622)
95%	(0.578174982564 ,	5.5884916841)
99%	(-0.451459486936 ,	6.6181261536)

The t-test of equality of means is 2.71, with a two-tail significance level .015. The null hypothesis is rejected at the .05 level. The 95% confidence interval for the mean differences contains only positive numbers, and the null hypothesis is also rejected at the 5% level.

SIMPLE REGRESSIONS

DESCRIPTION

This program will fit any of the following functions to data of the form (X,Y): $Y = AX$; $Y = A+BX$; $Y = Ae^{BX}$; $Y = 1/(A+BX)$; $Y = A+B/X$; $Y = A+B \log X$; $Y = AX^B$; and $Y = X/(A+BX)$.

Data, entered from the keyboard or from magnetic tape, may be added, deleted, corrected, or listed.

Data can be plotted, the best fitting curve selected on the basis of minimum residual error, maximum R-square, or smallest maximum absolute deviation, and a specified range of data values can be used to fit curves or plot data.

Each curve can be plotted against data, and the regression coefficients A and B can be calculated and displayed. Maximum absolute deviation as well as Y and deviation or residual for all values of X can be calculated.

For the curve $Y = A+BX$, 95% confidence bands for prediction of Y may be plotted.

The program will also calculate the R-square, and will estimate Y for any value of X entered from the keyboard.

HARDWARE REQUIREMENTS

A Tektronix 4050-Series Graphic System with a minimum 16K Read/Write memory is required.

All data must be stored internally or on tape when the data is to be listed, plotted, trimmed, plotted against a curve, or used to calculate goodness of fit. The number of data pairs which may be stored internally is dependent upon machine memory size as shown by the table below:

MEMORY SIZE	MAXIMUM DATA PAIR CAPACITY
16K	75 pairs
24K	75 pairs
32K	300 pairs

Data sets larger than allowable for internal storage must be stored on magnetic tape files.

TEST AND REGRESSIONS

SIMPLE REGRESSIONS

TAPE STRUCTURE

There are two versions of this program on the program tape. The first version, located in files 40, 41, 42, will run on a machine with 16K memory, but will require program overlay. Version two is totally contained in file 43 and may be executed on 24K or 32K machines without program overlay.

When file 40 is loaded, directly or indirectly, and either the ENTER DATA key or DATA FROM TAPE key is pressed, the program will be fully loaded, automatically.

All data tapes used by this program must be binary coded, and each must contain a Header File and one or more data files. The Header File, used to load data into memory, consists of the file number assigned to the first data file, and the number of files in the data set.

The initial entry in each data file is the number of data pairs in the file. This is followed by the data pairs in the form $X_1,Y_1; X_2,Y_2, \ldots$ When data is stored on data tapes, messages on the display screen will prompt insertion of the correct tape.

When large amounts of data are required, the data file should be stored on magnetic tape for efficient program execution.

METHODS

Each of the non-linear equations is transformed to an equation which is linear in parameters A and B. The least squares fit is calculated to the transformed data, and the parameters are then back-transformed to the original equation.

The transformations are:

ORIGINAL EQUATION	TRANSFORMED EQUATION	RESTRICTION
$Y = AX$	unchanged	none
$Y = A+BX$	unchanged	none
$Y = Ae^{BX}$	$\ln Y = \ln A+BX$	$Y > 0$
$Y = 1/(A+BX)$	$1/Y = A+BX$	$Y > 0$
$Y = A+B/X$	unchanged	$X > 0$
$Y = A+B \log X$	unchanged	$X > 0$
$Y = AX^B$	$\ln Y = \ln A+B \ln X$	$X,Y > 0$
$Y = x/(A+BX)$	$1/Y = A/X+B$	$X,Y > 0$

Goodness of fit measures used by this program are:

1. R-square, an index determination;
2. residual error, often called standard error of the estimate; and
3. maximum absolute residual.

To define these measures, let $Y = g(X)$ be any of the 8 equations; let $(X_i Y_i)$ be the data.

R-square is defined as:

$$\text{R-square } 1 - \frac{\Sigma(Y_i - g(X_i))^2}{\Sigma(Y_i - Y)^2} \quad \text{where } Y = \Sigma Y_i / N$$

$$\text{Residual error is: } \frac{\Sigma(Y_i - g(X_i))^2}{N - 2}$$

Maximum absolute residual is defined as $\max(|Y_i - g(X_i)|)$.

With this definition, R-square may be negative. A negative R-square for a particular equation indicates that the equation is not appropriate for the data.

When the SELECT BEST FIT key is pressed, and when all data is available, R-square, residual error, and maximum absolute deviation are calculated and displayed for each equation that may be fit. A message indicates which equation has the smallest maximum absolute residual, and which equation has the maximum R-square.

REFERENCE

Draper, N., Smith, H., *Applied Regression Analysis*, New York: John Wiley and Sons, 1966.

VARIABLES

VARIABLE	USAGE
A	Data array
A1	Scratch
A2	Scratch
A3	Scratch
A4	Scratch
A5	Scratch
B	Coefficient matrix
B1	Flag = 1 if coefficient calculated
B2	Flag = −1 if equations 3, 4, 7, 8 can not be fit
B3	Flag = −1 if equations 5, 6, 7, 8 can not be fit
B4	Flag = 4 to change range of plot
B5	Flag = 4 to change range of fit
C	Summary statistics matrix
D	Residual error and maximum residual matrix
D3	Scratch

TEST AND REGRESSIONS

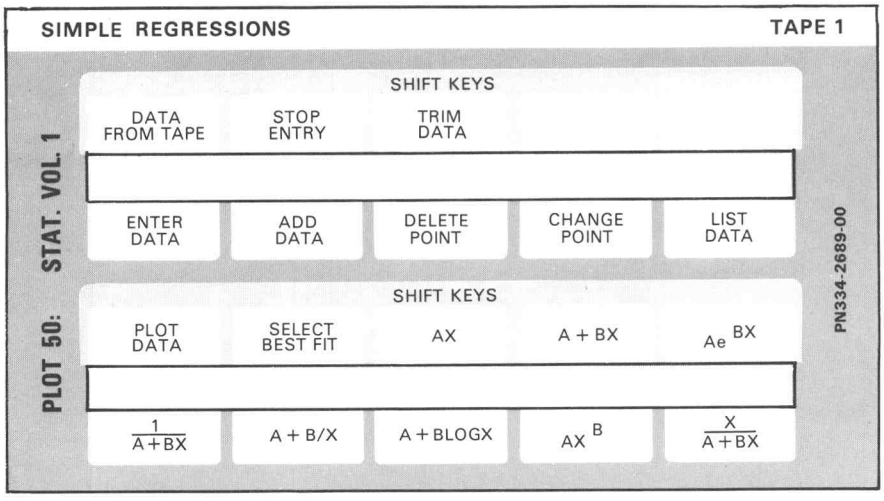
SIMPLE REGRESSIONS

VARIABLES

VARIABLE	USAGE
D4	Scratch
E1	Flag = −1 data on separate data tape; 0 data not on tape; 1 data on program tape
E2	Flag = 0 data tape in; 1 program tape in
E3	Scratch
E4	Flag = 0 stop entry not performed; 1 stop entry performed
E8	Overlay key pressed
E9	Flag = 1 all data in memory; 0 all data not in memory
E$	String variable for alpha information
F	Header File number, number of files used
G	Array for drawing axes
I	Scratch
J	Scratch
K	Scratch
L	Scratch
N	Number of data pairs
S	Scratch
S1	Scratch
S2	Equation number to plot, etc.
S3	Scratch
W0	Dimension of data array
X	Scratch
X1	Scratch
X2	Scratch
X9	Scratch
Y	Scratch
Y1	Scratch
Y2	Scratch

SIMPLE REGRESSIONS

FUNCTION KEYS



KEY No.	KEY NAME	FUNCTION
1	ENTER DATA	allows entry of data from keyboard to memory and causes data to be stored to tape when input was from tape file.
2	ADD DATA	allows additions to data previously entered.
3	DELETE POINT	deletes a designated data point from storage, tape file, and calculations.
4.	CHANGE POINT	permits correction of a data pair.
5	LIST DATA	lists data previously stored.
6	$\frac{1}{A+BX}$	produces a plot of regression curve against the data, estimation of Y for X, and residual calculation for equation $Y = 1/(A+BX)$.
7	A+B/X	produces a plot of regression curve against the data, estimation of Y for X, and calculation of residuals for equation $Y = A+B/X$.
8	A+BlogX	produces a plot of regression curve against the data, estimation of Y for X, and calculation of residuals for equation $Y = A+B\log X$.
9	AX^B	produces a plot of regression curves against the data, estimation of Y for X, and calculation of residuals for equation $Y = AX^B$.

TEST AND REGRESSIONS

SIMPLE REGRESSIONS

KEY No.	KEY NAME	FUNCTION
10	X A+BX	produces a plot of regression curves against the data, estimation of Y for X, and calculation of residuals for equation Y = X/(A+BX).
11	DATA FROM TAPE	allows entry of data from data tape or program tape.
12	STOP ENTRY	terminates data entry and saves data for later analysis or addition of more data.
13	TRIM DATA	allows execution to be restricted to a portion of data previously entered.
16	PLOT DATA	initiates plot of data from taped data file or from internal storage.
17	SELECT BEST FIT	lists coefficients for equations and descriptive statistics for data in memory or tape files; calculates R-square.
18	AX	permits selection of plot of regression curve against data; calculates residuals; estimates Y for X for equation Y = AX.
19	A+BX	produces a plot of regression curve against the data, estimates Y for X, calculates residuals for equations Y = A + BX.
20	Ae^{BX}	produces a plot of regression curve against the data, estimates Y for X, calculates residuals for equation $Y = Ae^{BX}$.

PROGRAM LOADING

This program may be loaded automatically from the directory, or manually from the keyboard. The STATISTICS, VOLUME 1 program tape is required.

AUTOMATIC LOADING FROM THE DIRECTORY

1. Insert the program tape.
2. Press AUTO LOAD. The program directory will be displayed with the message ENTER THE PROGRAM NUMBER YOU WANT.
3. Enter 26; press RETURN.
4. When the I/O light goes out, execute the program.

MANUAL LOADING FROM THE KEYBOARD

1. Insert the program tape.
2. Enter FIND 40; press RETURN.
3. Enter OLD; press RETURN.
4. When the I/O light goes out, execute the program.

PROGRAM EXECUTION

Program execution procedures are determined by the input method and data storage needs. The 5 options from which one selection must be made are as follows:

1. Input data from the program tape;
2. Input data from a previously created data tape;
3. Input from the keyboard, data to be stored on the program tape;
4. Input from the keyboard, data to be stored on a data tape; and
5. Input from the keyboard, no data to be stored on tape.

Execution procedures for each of these options are described on the following pages.

OPTION 1, EXECUTION WITH DATA INPUT FROM THE PROGRAM TAPE

Execute the program using a data set previously stored on the program tape.

1. Press DATA FROM TAPE (key No. 11). IS DATA ON PROGRAM TAPE is displayed.

2. Enter YES from the keyboard; press RETURN.
   When all data from the program tape has been read into memory, the I/O light goes out and ALL DATA ENTERED is displayed.

3. Use the appropriate function keys to execute program operations.

OPTION 2, EXECUTION WITH DATA INPUT FROM DATA TAPE

To execute the program with input from an existing data tape:

1. Press DATA FROM TAPE (key No. 11). IS DATA ON PROGRAM TAPE is displayed.

2. Enter NO from the keyboard; press RETURN.
   HEADER FILE is displayed.

SIMPLE REGRESSIONS

3. Enter the numeric designation of the data file to be used. Press RETURN. The alarm bell sounds and INSERT DATA TAPE, PRESS RETURN is displayed.

4. Insert the correct data tape and press RETURN. When the data transfer is complete, the I/O light goes out and ALL DATA ENTERED is displayed.

5. Use the appropriate function keys to execute program operations.

OPTION 3, EXECUTION WITH KEYBOARD INPUT, DATA TO BE STORED ON PROGRAM TAPE

To execute the program and store keyboard entered data on the program tape:

1. Press ENTER DATA (key No. 1). DO YOU WISH TO STORE DATA ON TAPE is displayed.

2. Enter YES from the keyboard; press RETURN. DO YOU WISH TO STORE DATA ON PROGRAM TAPE is displayed.

3. Enter YES from the keyboard and press RETURN.

   ENTER DATA
   X,Y

   is displayed.

4. Enter the value of X and Y, separated by a comma. Press RETURN after each X,Y pair.

5. When all data has been entered, use the appropriate function keys to perform other program operations. Data storage will be automatic.

6. If no analysis is desired, press STOP ENTRY (key No. 12) to store the data and update the Header File.

OPTION 4, EXECUTION WITH KEYBOARD INPUT, DATA TO BE STORED ON A DATA TAPE

To execute the program and store keyboard entered data on a data tape, follow the steps below.

1. Press ENTER DATA (key No. 1). DO YOU WISH TO STORE DATA ON TAPE is displayed.

2. Enter YES from the keyboard and press RETURN. DO YOU WISH TO STORE DATA ON PROGRAM TAPE is displayed.

3. Enter NO from the keyboard and press RETURN. HEADER FILE is displayed.

4. Enter the number of the header file and press RETURN. INSERT DATA TAPE, PRESS RETURN is displayed and the alarm bell sounds.

5. Insert the correct data tape and press RETURN.

   ENTER DATA
   X,Y

   is displayed.

6. Enter the X, Y pair values with a comma as a value delimiter. Press RETURN after each pair.

7. When all data pairs have been entered, use the appropriate function keys to perform program operations. Data storage will be automatic.

8. If no data analysis is desired, press the STOP ENTRY key (No. 12) to store the data and update the Header File.

OPTION 5, EXECUTION WITH KEYBOARD INPUT AND NO DATA STORAGE

To execute the program without storing data for later use, proceed as follows:

1. Press ENTER DATA (key No. 1). DO YOU WISH TO STORE DATA ON TAPE is displayed.

2. Enter NO from the keyboard and press RETURN.

   ENTER DATA
   X,Y

   is displayed.

3. Enter the X and Y values, separated by commas. Press RETURN after each pair.

4. When all data has been entered, use the function keys to perform any of the operations described on the next pages.

SIMPLE REGRESSIONS

PROGRAM OPERATIONS

Upon completion of the initial data entries, operations are performed with the function keys. The operations described here may be performed in any sequence.

ADD DATA

ADD DATA (key No. 2) will permit addition of new data to the file currently in memory. If the file also resides on tape, the alarm bell sounds to indicate that the tape should be inserted. A message on the screen will identify the kind of tape required; program tape or data tape. Data entered will be added to the tape file automatically.

When the tape has been inserted, press RETURN.

```
ENTER DATA
X,Y
```

will be displayed, and values may be entered. The RETURN key must be pressed after each pair of values has been typed.

Other operations may now be performed, or the STOP ENTRY (key No. 12) may be used to update the file without other operations.

DELETE POINT

DELETE POINT (key No. 3) initiates deletion of a data pair value. The values specified will be deleted from internal storage and from the tape file, when applicable. All subsequent calculations and displays will exclude the deleted pair.

If the alarm bell sounds when DELETE POINT is pressed, insert the tape indicated by the message on the screen and press RETURN.

DELETE X,Y will appear on the screen. Type the value pair to be deleted, and press RETURN. The message CORRECTION DONE indicates that the values have been deleted.

```
ENTER DATA
X,Y
```

is displayed to allow other values to be entered.

If the pair selected for deletion is not found, DATA NOT FOUND is displayed and all processing stops.

CHANGE POINT

If an incorrect value has been entered, CHANGE POINT (key No. 4) provides a method of correcting the data. When the key is pressed, any necessary tape insertion is indicated by the alarm bell and a message on the screen.

The screen displays the message CHANGE: INCORRECT X,Y TO CORRECT X,Y. Enter the incorrect values followed by the correct values, using a comma to separate each entry. When RETURN is pressed, CORRECTION DONE will indicate that the data has been changed internally and on tape, if applicable. Additional data may be added or other keys may be used to perform analysis.

If the designated values are not found, all processing stops and DATA NOT FOUND is displayed. Analysis may be resumed by pressing any other function key.

LIST DATA

Data currently in internal storage or residing on a tape file will be listed when the LIST DATA key (No. 5) is pressed. If a tape insertion is required, the alarm will sound and a message will appear on the screen. Listing of the data will continue until the entire data set has been displayed. The HOME PAGE key must be used to clear the screen when the display area is full.

$\frac{1}{A+BX}$ (Key No. 6)

This key causes calculation and display of the details for curve $Y = 1/(A+BX)$. If the alarm bell sounds when the key is pressed, tape insertion requirements will be shown on the display screen. When the displayed instructions have been satisfied, the following message will appear on the display screen:

FOR EQUATION Y = A+BX SELECT OPTION

1 PLOT EQUATION
2 RESIDUALS
3 ESTIMATE Y FOR X
4 PLOT EQUATION AND CONFIDENCE BANDS
ENTER OPTION

Enter option number 1, 2, 3, or 4, and press RETURN. The appropriate operation will be performed and results will be displayed. If the operation is not completed, a displayed message will identify the reason.

SIMPLE REGRESSIONS

A+B/X (Key No. 7)

This key causes calculation and display of the details for curve Y = A+B/X. If the alarm bell sounds when the key is pressed, tape insertion requirements will be shown on the display screen. When the displayed instructions have been satisfied, the following message will appear on the display screen:

```
FOR EQUATION Y = A+B/X SELECT OPTION
  1 PLOT EQUATION
  2 RESIDUALS
  3 ESTIMATE Y FOR X
    ENTER OPTION
```

Enter option number 1, 2, or 3, and press RETURN. The appropriate operation will be performed and results will be displayed. If the operation is not completed, a displayed message will identify the reason.

A+BlogX (Key No. 8)

This key causes calculation and display of the details for curve Y = A+BlogX. If the alarm bell sounds when the key is pressed, tape insertion requirements will be shown on the display screen. When the displayed instructions have been satisfied, the following message will appear on the display screen:

```
FOR EQUATION Y = A+BlogX SELECT OPTION
  1 PLOT EQUATION
  2 RESIDUALS
  3 ESTIMATE Y FOR X
    ENTER OPTION
```

Enter option number 1, 2, or 3, and press RETURN. The appropriate operation will be performed and results will be displayed. If the operation is not completed, a displayed message will identify the reason.

AX^B (Key No. 9)

This key causes calculation and display of the details for curve $Y = AX^B$. If the alarm bell sounds when the key is pressed, tape insertion requirements will be shown on the display screen. When the displayed instructions have been satisfied, the following message will appear on the display screen:

FOR EQUATION $Y = AX^B$ SELECT OPTION

1 PLOT EQUATION
2 RESIDUALS
3 ESTIMATE Y FOR X
ENTER OPTION

Enter option number 1, 2, or 3, and press RETURN. The appropriate operation will be performed and results will be displayed. If the operation is not completed, a displayed message will identify the reason.

$\frac{X}{A+BX}$ (Key No. 10)

This key causes calculation and display of the details for curve

$$Y = \frac{X}{A+BX}$$

If the alarm bell sounds when the key is pressed, tape insertion requirements will be shown on the display screen. When the displayed instructions have been satisfied, the following message will appear on the display screen:

FOR EQUATION $Y = \frac{X}{A+BX}$ SELECT OPTION

1 PLOT EQUATION
2 RESIDUALS
3 ESTIMATE Y FOR X
ENTER OPTION

Enter option number 1, 2, or 3, and press RETURN. The appropriate operation will be performed and results will be displayed. If the operation is not completed, a displayed message will identify the reason.

STOP ENTRY

STOP ENTRY (key No. 12) should be used when keyboard entered data is to be stored to tape, and when no immediate analysis is desired. When the key is pressed, the last data file entered will be written to the specified tape file. If that file already exists on tape, the data will be added to it. The control information required for the Header File will also be written or updated.

When the operation has been completed, REMOVE TAPE will be displayed.

SIMPLE REGRESSIONS

TRIM DATA

TRIM DATA (key No. 13) makes possible the change of plotting and listing range without altering the fit of the curves. This permits a close examination of the data and regression equations within the selected range, yet retains the original fit.

The TRIM DATA may also be used to change the range of fit to a narrower range within the original data.

When the key is pressed, the alarm and a message on the screen will indicate any required tape insertions. When the tape requirement has been satisfied, the message displayed will be:

DO YOU WISH TO

1. CHANGE PLOT RANGE ONLY
2. CHANGE RANGE OF FIT AND PLOT
3. RESET FIT AND PLOT RANGE TO ORIGINAL DATA
4. RESET PLOT RANGE ONLY

SELECT OPTION

Enter the number of the option desired and press RETURN.

If option 1 was selected, CHANGE PLOT RANGE TO will appear on the screen. The minimum and maximum value of the range chosen should be typed. A comma serves as a delimiter between the two values, and the RETURN key causes the values to be entered.

The X data range, range of plot, and range of data fit are displayed, and plots, equations, and listings are based on them until further alterations are made.

Option 2 causes CHANGE RANGE OF FIT TO to be displayed. When the minimum and maximum ranges have been entered through the keyboard, press RETURN. The summaries will be re-calculated to conform to the new data limits, and ALL DATA ENTERED will be displayed to indicate completion. Use other function keys to perform operations based upon the new fit.

Options 3 and 4 are used to reset altered ranges to their original form. Data is re-entered from storage, and ALL DATA ENTERED is displayed to acknowledge the restoration. All subsequent operations and calculations will be based on the original data.

If data is not available to permit the use of this key, OPERATION MAY NOT BE PERFORMED will be displayed.

PLOT DATA

PLOT DATA (key No. 16) provides a plot of available data. When the key is pressed, the plot will appear or tape insertion requirements will be signaled by the alarm bell and a displayed message.

SELECT BEST FIT

To cause calculation of the coefficients for all functions that can be fit, press SELECT BEST FIT (key No. 17). Any necessary tape insertions will be indicated by the alarm bell and a displayed message.

If data is available, R-square and standard error of the estimate will be calculated and displayed. The maximum absolute residual is calculated for each regression that may be calculated.

AX (Key No. 18)

This key causes calculation and display of the details for curve Y = AX. If the alarm bell sounds when the key is pressed, tape insertion requirements will be shown on the display screen. When the displayed instructions have been satisfied, the following message will appear on the display screen:

FOR EQUATION Y = AX SELECT OPTION
1 PLOT EQUATION
2 RESIDUALS
3 ESTIMATE Y FOR X
ENTER OPTION

Enter option number 1, 2, or 3, and press RETURN. The appropriate operation will be performed and results will be displayed. If the operation is not completed, a displayed message will identify the reason.

A+BX (Key No. 19)

This key causes calculation and display of the details for curve Y = A+BX. If the alarm bell sounds when the key is pressed, tape insertion requirements will be shown on the display screen. When the displayed instructions have been satisfied, the following message will appear on the display screen:

FOR EQUATION Y = A+BX SELECT OPTION
1 PLOT EQUATION
2 RESIDUALS
3 ESTIMATE Y FOR X
4 PLOT EQUATION AND CONFIDENCE BANDS
ENTER OPTION

SIMPLE REGRESSIONS

Enter option number 1, 2, 3, or 4, and press RETURN. The appropriate operation will be performed and results will be displayed. If the operation is not completed, a displayed message will identify the reason.

Ae^{BX} (Key No. 20)

This key causes calculation and display of the details for curve $Y = Ae^{BX}$. If the alarm bell sounds when the key is pressed, tape insertion requirements will be shown on the display screen. When the displayed instructions have been satisfied, the following message will appear on the display screen:

FOR EQUATION $Y = Ae^{BX}$ SELECT OPTION

1 PLOT EQUATION
2 RESIDUALS
3 ESTIMATE Y FOR X
ENTER OPTION

Enter option number 1, 2, or 3, and press RETURN. The appropriate operation will be performed, and results will be displayed. If the operation is not completed, a displayed message will identify the reason.

EXAMPLE

Find an equation which adequately represents the data below:

X	Y
3	5.5
4	7.75
5	10.6
7	13.4
9	18.5
12	23.6
13	26.2
14	27.8
17	30.5
20	33.5
23	35
25	35.4
34	41
38	42.1
42	44.4
45	46.2

SIMPLE REGRESSIONS

Load the program and press ENTER DATA. Because the number of observations is small, data may be stored internally and there is no need to create a tape file.

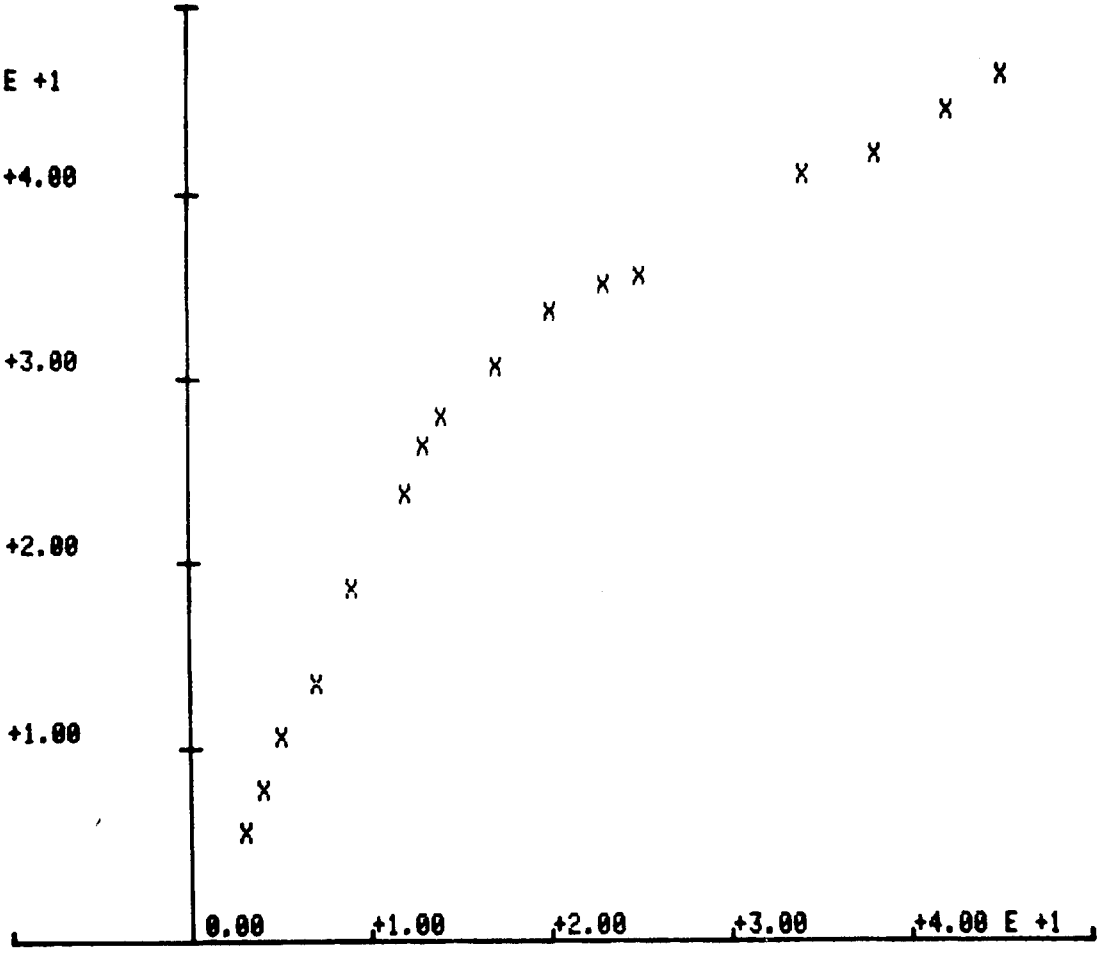
```
                    SIMPLE REGRESSIONS

DO YOU WISH TO STORE DATA ON TAPE NO


                    ENTER DATA
X,Y = 3,5.5
X,Y = 4,7.75
X,Y = 5,10.6
X,Y = 7,13.4
X,Y = 9,18.5
X,Y = 12,23.6
X,Y = 13,26.2
X,Y = 14,27.8
X,Y = 17,30.5
X,Y = 20,33.5
X,Y = 23,35
X,Y = 25,35.4
X,Y = 34,41
X,Y = 38,42.1
X,Y = 42,44.4
X,Y = 45,46.2
X,Y =
```

List the data by pressing the LIST DATA key.

```
                    DATA

X                   Y
 3                    5.5
 4                    7.75
 5                    10.6
 7                    13.4
 9                    18.5
 12                   23.6
 13                   26.2
 14                   27.8
 17                   30.5
 20                   33.5
 23                   35
 25                   35.4
 34                   41
 38                   42.1
 42                   44.4
 45                   46.2
```

SIMPLE REGRESSIONS

Press the PLOT DATA key to produce a plot of all untrimmed data.



There is a break point in the plot somewhere between X = 14 and X = 17. The data is nearly linear below 14 and above 17.

SELECT BEST FIT (key No. 17) provides a table of criteria for all curves.

SELECT BEST FIT

EQUATION	A	B	RES ERROR	R-SQUARE	MAX DEVIATION
Y = A*X	1.25433		56.76697	0.70018	10.24496
Y = A + B*X	9.95581	0.90726	20.24863	0.89305	7.17758
Y = A*EXP(B*X)	10.86252	0.03969	79.24698	0.58145	18.61200
Y = 1/(A + B*X)	0.09807	-0.00227	14257.32734	-74.30152	341.45102
Y = A + B/X	40.61515	-133.32444	32.27480	0.82954	9.32633
Y = A + B*LOG(X)	-14.18756	15.61145	1.54151	0.99186	2.79092
Y = A*X↑B	3.14259	0.75176	20.52394	0.89160	8.76724
Y = X/(A + B*X)	0.49607	0.00542	48.55325	0.74356	14.60028

EQUATION Y = A + B*LOG(X) HAS MAXIMUM R-SQUARE

EQUATION Y = A + B*LOG(X) HAS MINIMUM MAXIMUM ABSOLUTE RESIDUAL

The equation Y −14.18756 + 15.61145 log X has the highest R-square and the smallest maximum deviation.

The equation (Y = 1/(A+BX) has a negative R-square indicating that the equation form is not appropriate for this data.

TEST AND REGRESSIONS

SIMPLE REGRESSIONS

Any of the individual function keys except Y = A+BX will provide the following display, using the equation corresponding to the key:

```
FOR EQUATION Y = A*X SELECT OPTION
  1 PLOT EQUATION
  2 RESIDUALS
  3 ESTIMATE Y FOR X
    ENTER OPTION
```

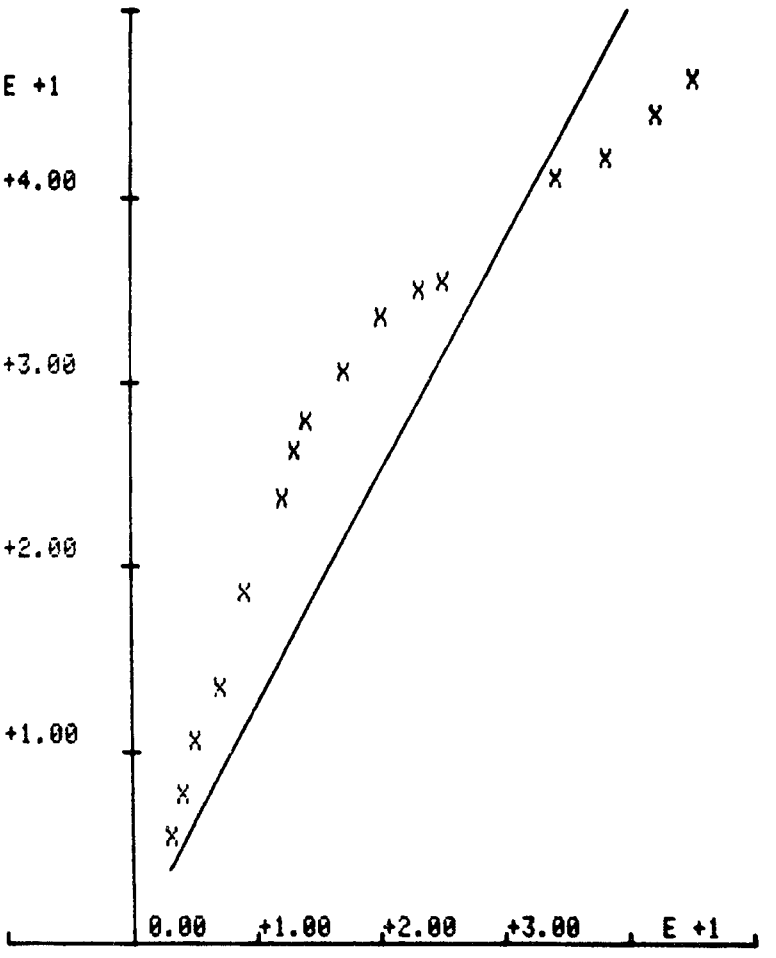
For the Y = A+BX key, the display will be:

```
FOR EQUATION Y = A+BX SELECT OPTION
  1 PLOT EQUATION
  2 RESIDUALS
  3 ESTIMATE Y FOR X
  4 PLOT EQUATION AND CONFIDENCE BANDS
    ENTER OPTION
```

All equations are plotted against the data, and for Y = A+BX, the 95% confidence bands are plotted.

SIMPLE REGRESSIONS

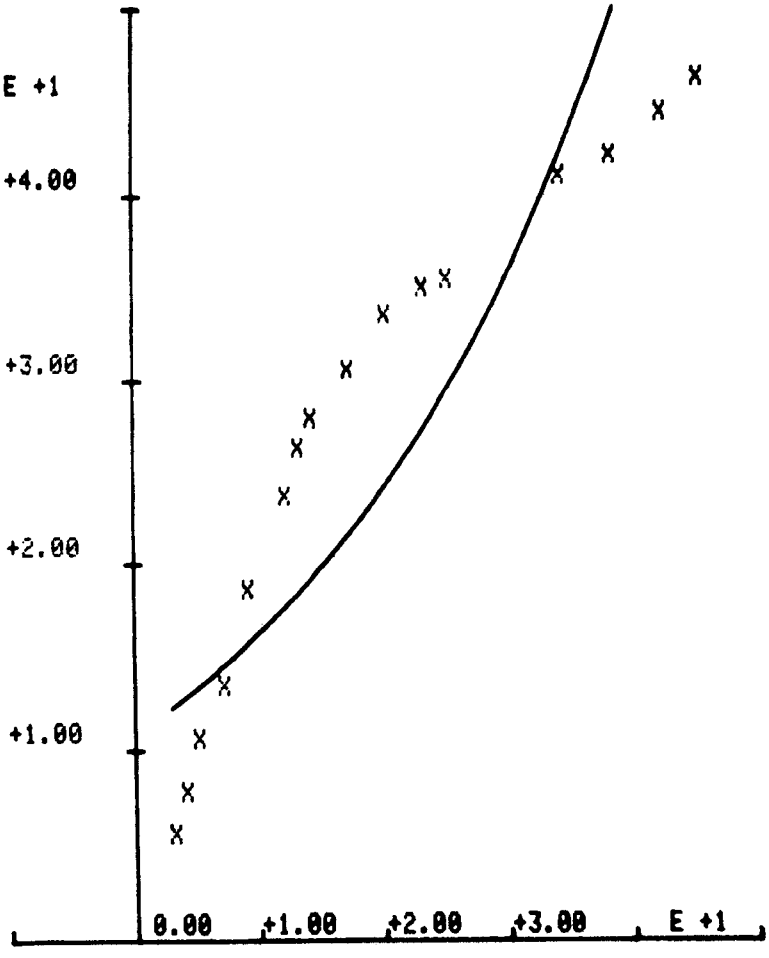
```
Y = A*X

A =
 1.25433247394

R-SQUARE =
 0.700179490795

RES ERROR
 56.7669678487

MAX(ABS(RESIDUAL))
 10.2449613272
```



TEST AND REGRESSIONS

SIMPLE REGRESSIONS

```
Y = A*EXP(B*X)

A =
 10.8625246194

B =
 0.0396927121718

R-SQUARE =
 0.581449014039

RES ERROR
 79.2469815562

MAX(ABS(RESIDUAL))
 18.6120021636
```



SIMPLE REGRESSIONS

Y = 1/(A + B*X)

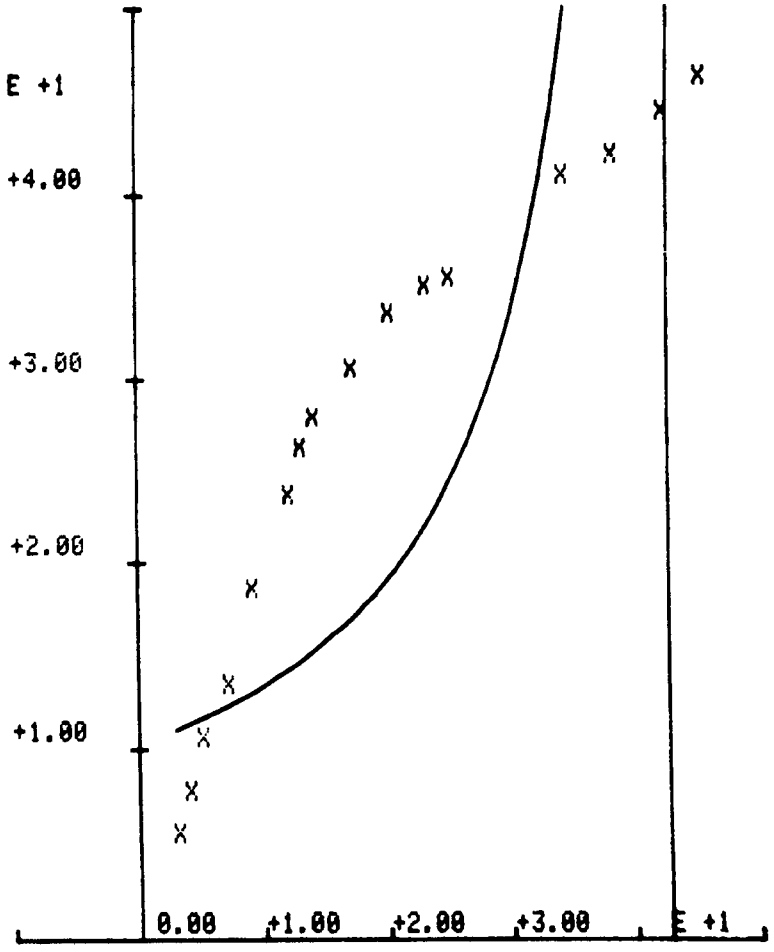
A =
0.0980729903147

B =
-0.00227336467726

R-SQUARE =
-74.3015231463

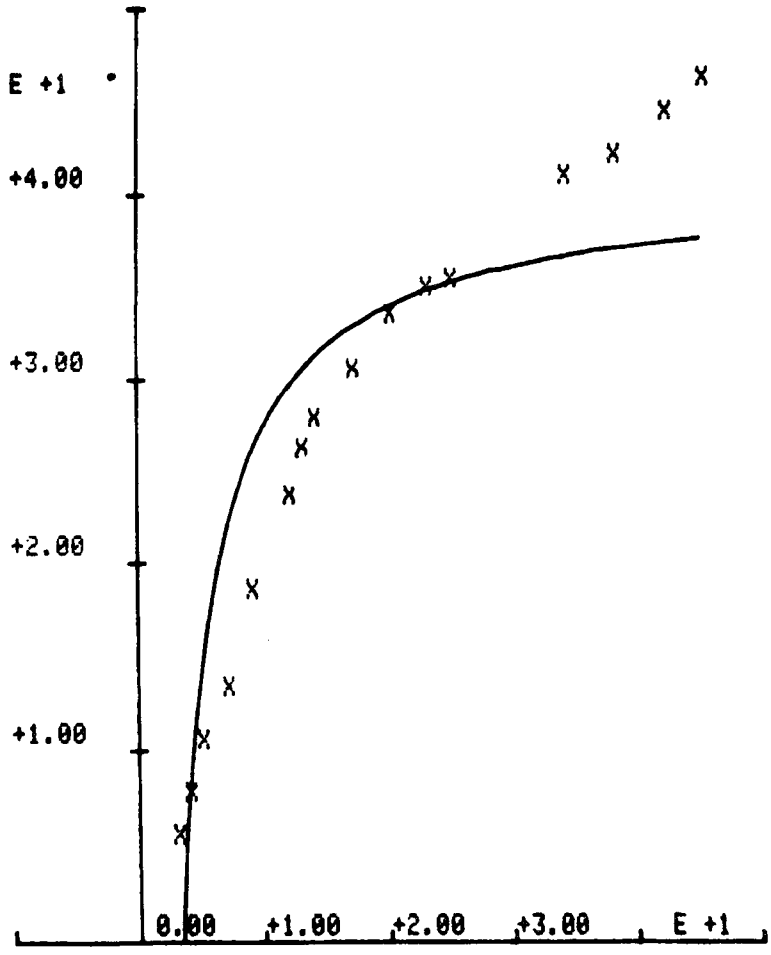
RES ERROR
14257.3273415

MAX(ABS(RESIDUAL))
341.451017642



SIMPLE REGRESSIONS

```
Y = A + B/X

A =
 40.6151537502

B =
 -133.324443909

R-SQUARE =
 0.829537338628

RES ERROR
 32.2748048264

MAX(ABS(RESIDUAL))
 9.32632755281
```



SIMPLE REGRESSIONS

Y = A + B*LOG(X)

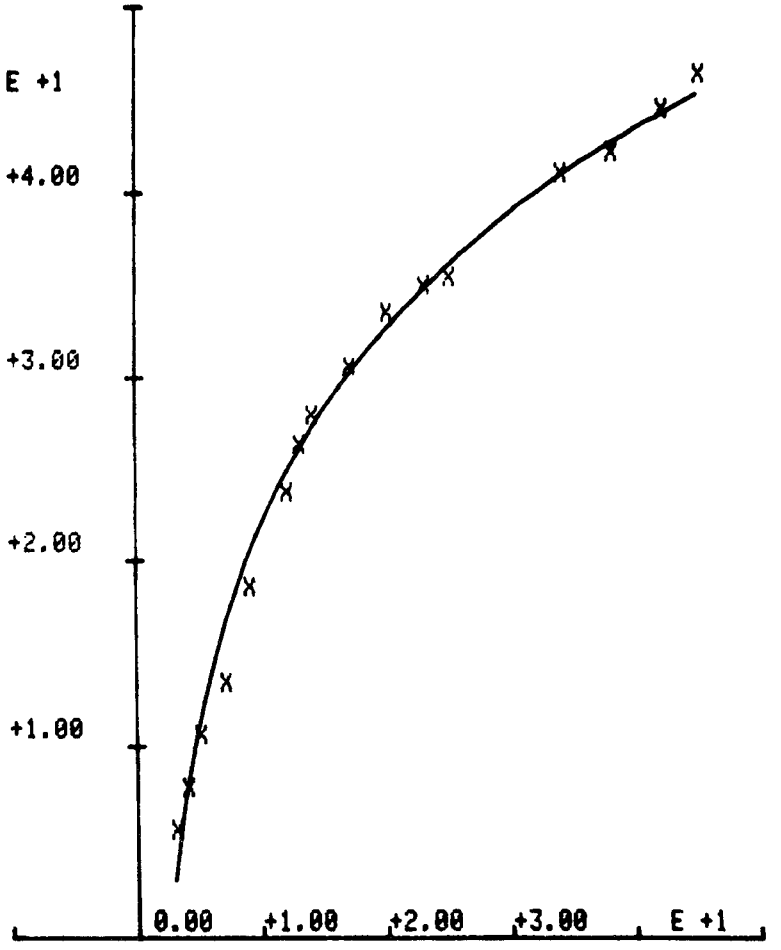
A =
-14.1875642197

B =
15.6114538108

R-SQUARE =
0.99185833506

RES ERROR
1.54151439852

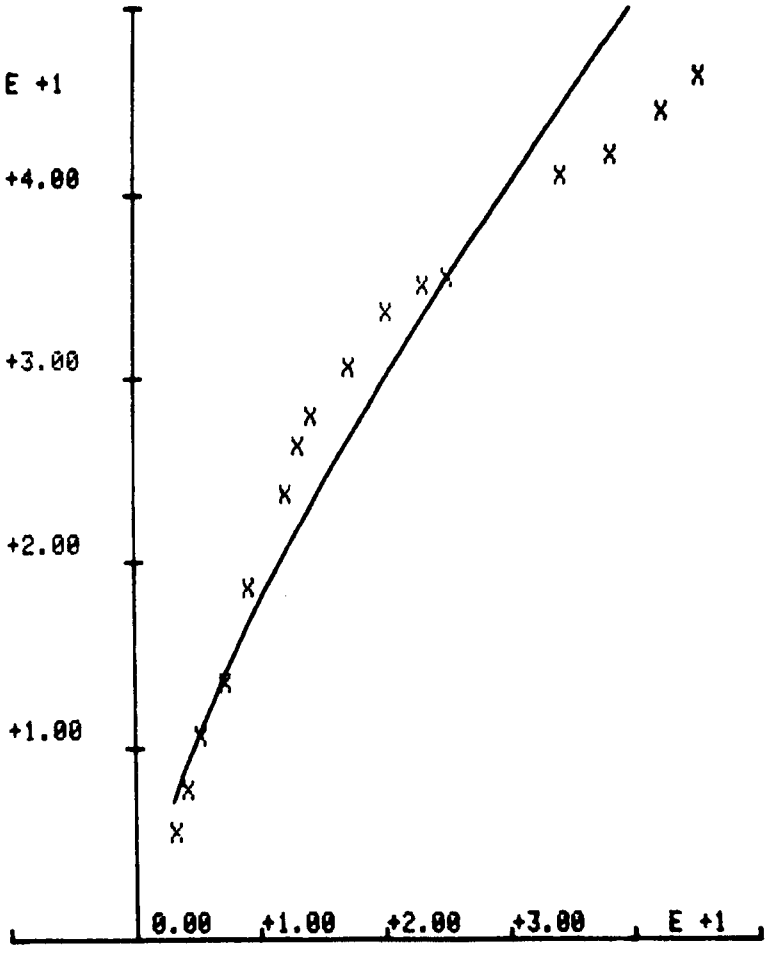
MAX(ABS(RESIDUAL))
2.79092219237



TEST AND REGRESSIONS

SIMPLE REGRESSIONS

```
Y = A*X↑B

A =
 3.14258996212
B =
 0.751758295473

R-SQUARE =
 0.891600734877
RES ERROR
 20.5239381869
MAX(ABS(RESIDUAL))
 8.76724120826
```



SIMPLE REGRESSIONS

Y = X/(A + B*X)

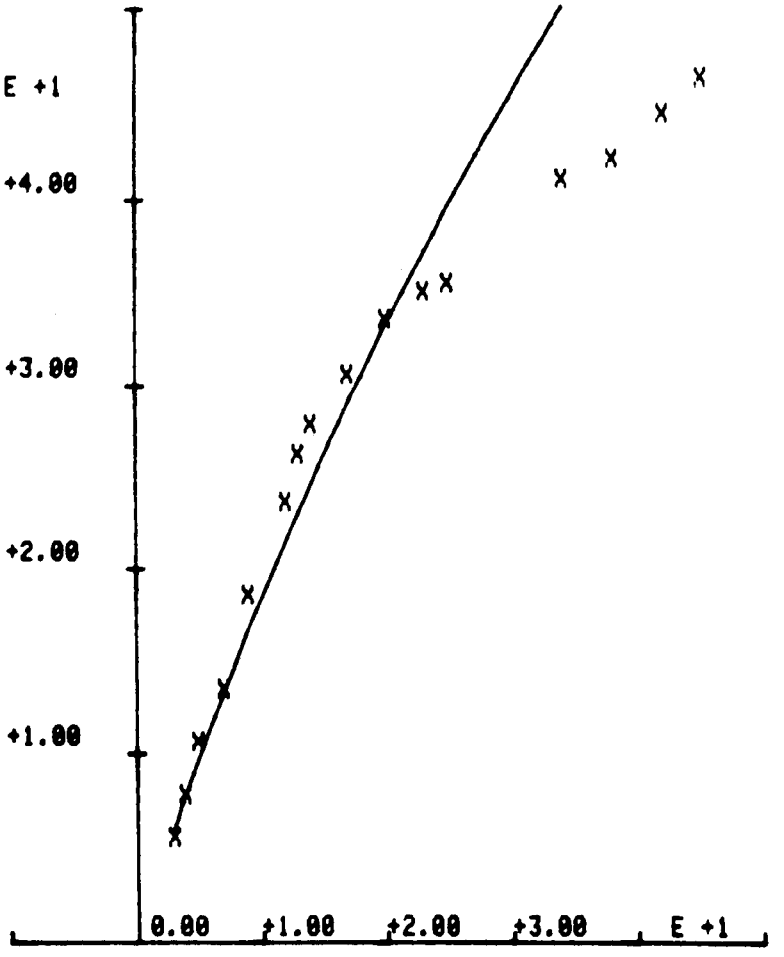
A =
0.496065131274

B =
0.00542362425122

R-SQUARE =
0.743561089159

RES ERROR
48.5532475596

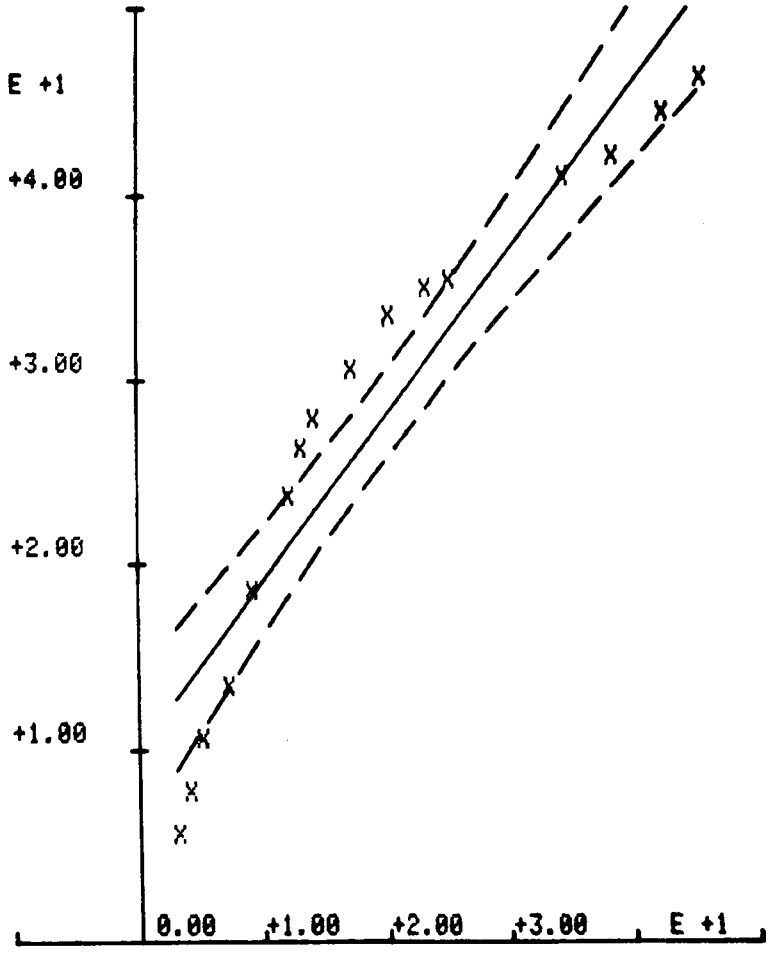
MAX(ABS(RESIDUAL))
14.6002757187



TEST AND REGRESSIONS

SIMPLE REGRESSIONS

```
Y = A + B*X

A =
 9.95580897533

B =
 0.90725741606

R-SQUARE =
 0.893054784983

RES ERROR
 20.2486334192

MAX(ABS(RESIDUAL))
 7.17758122351
```



The equation Y = A+B log X appears to be the best fitting equation. The extreme oscillation about X = 30 on the Y = 1/A+BX plot indicates that the equation is inappropriate.

To illustrate the use of TRIM DATA (key No. 13) data is trimmed to the range X = 3 to X = 14, and the best fitting equation in this range is found.

```
                    TRIM DATA

RANGE OF X DATA IS  3  TO  45

EQUATIONS HAVE BEEN FIT TO DATA WITH
   X RANGE FROM  3  TO  45

THE  PLOT RANGE IS  3  TO  45


DO YOU WISH TO :
   1   CHANGE PLOT RANGE ONLY
   2   CHANGE RANGE OF FIT AND PLOT
   3   RESET FIT AND PLOT RANGE TO ORIGINAL DATA
   4   RESET PLOT RANGE ONLY

    SELECT OPTION
2
CHANGE RANGE OF FIT TO 3,14
ALL DATA ENTERED
```

All data is automatically re-entered from storage or tape, and no further operation should be attempted until ALL DATA ENTERED is displayed.

If option 1 had been excercised (rather than option 2, as shown), equations in the 3 to 14 range could have been closely observed without changing the fit.

The LIST DATA key is used to verify that only data in the 3 to 14 range is being considered.

```
                    DATA

X              Y
 3               5.5
 4               7.75
 5               10.6
 7               13.4
 9               18.5
 12              23.6
 13              26.2
 14              27.8
```

TEST AND REGRESSIONS

SIMPLE REGRESSIONS

The SELECT BEST FIT key generates the display below:

SELECT BEST FIT

EQUATION	A	B	RES ERROR	R-SQUARE	MAX DEVIATION
Y = A*X	1.99390		0.24948	0.99711	0.63048
Y = A + B*X	-0.16271	2.00973	0.24293	0.99719	0.71408
Y = A*EXP(B*X)	4.62083	0.13632	4.34318	0.94969	3.35963
Y = 1/(A + B*X)	0.17276	-0.01092	98.26507	-0.13833	22.53674
Y = A + B/X	30.06560	-84.45703	11.38286	0.86814	4.60031
Y = A + B*LOG(X)	-12.45100	14.62717	2.68537	0.96889	2.61215
Y = A*X↑B	1.85701	1.03141	0.28908	0.99665	0.83352
Y = X/(A + B*X)	0.54364	-0.00494	1.07096	0.98759	1.70227

EQUATION Y = A + B*X HAS MAXIMUM R-SQUARE

EQUATION Y = A*X HAS MINIMUM MAXIMUM ABSOLUTE RESIDUAL

The R-square column indicates that the Y A+BX has the maximum R-square. Y = AX has the smallest maximum deviation.

For data in the restricted range, four equations fit better than Y = A+B log X.

The equations Y = AX and Y = A+BX are plotted, and residuals are calculated.

SIMPLE REGRESSIONS

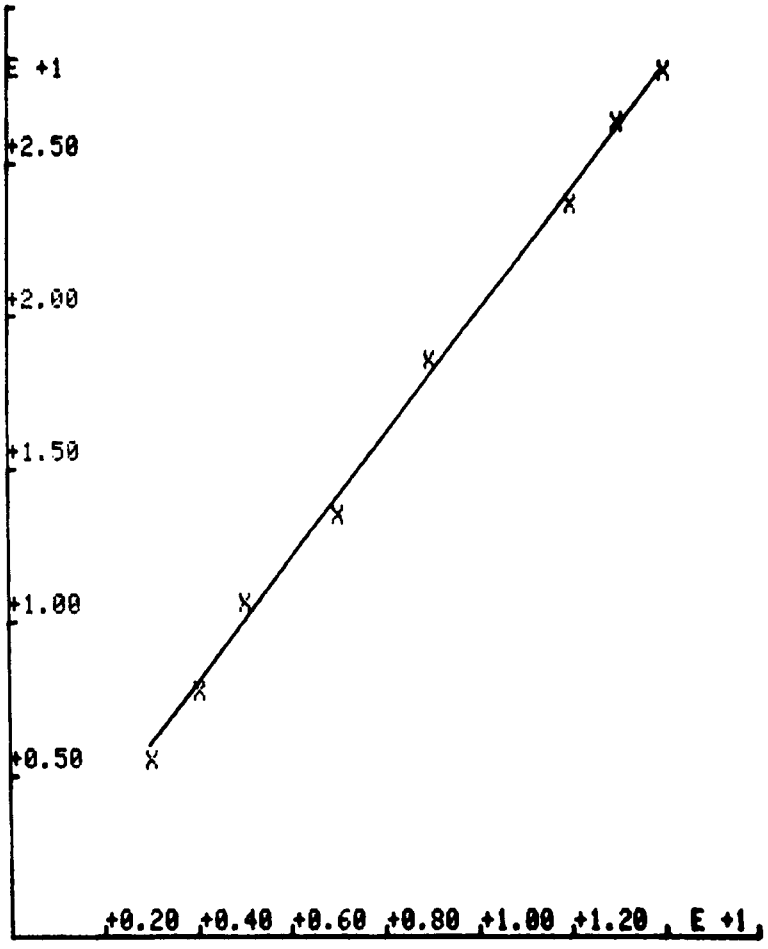
Y = A*X

A =
1.993904209

R-SQUARE =
0.997109927539

RES ERROR
0.249482946299

MAX(ABS(RESIDUAL))
0.630478955007

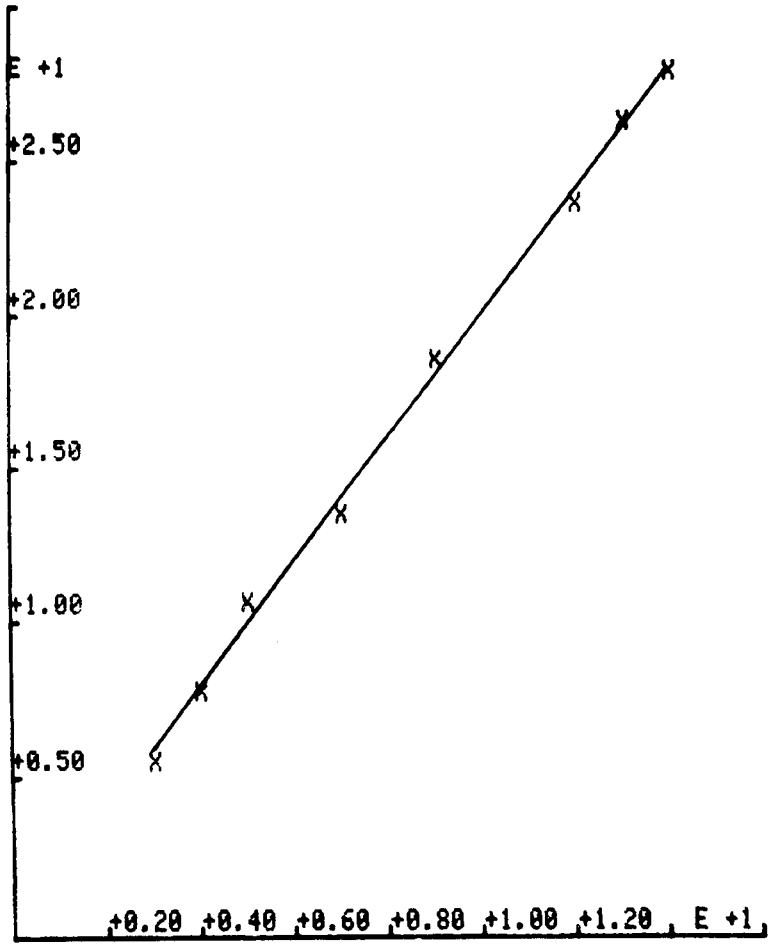


RESIDUALS FOR EQUATION : Y = A*X

X	Y	YESTIMATE	RESIDUAL
3	5.5	5.981712627	-0.481712626996
4	7.75	7.97561683599	-0.225616835994
5	10.6	9.96952104499	0.630478955007
7	13.4	13.957329463	-0.55732946299
9	18.5	17.945137881	0.554862119013
12	23.6	23.926850508	-0.326850507982
13	26.2	25.920754717	0.279245283019
14	27.8	27.914658926	-0.114658925979

SIMPLE REGRESSIONS

```
Y = A + B*X

A =
 -0.162707722385

B =
 2.00972629521

R-SQUARE =
 0.997185818379

RES ERROR
 0.242931736722

MAX(ABS(RESIDUAL))
 0.714076246334
```



RESIDUALS FOR EQUATION : Y = A + B*X

X	Y	YESTIMATE	RESIDUAL
3	5.5	5.86647116325	-0.366471163256
4	7.75	7.87619745846	-0.126197458456
5	10.6	9.88592375367	0.714076246334
7	13.4	13.9053763441	-0.505376344086
9	18.5	17.9248289345	0.575171065494
12	23.6	23.9540078201	-0.354007820137
13	26.2	25.9637341153	0.236265884653
14	27.8	27.9734604106	-0.173460410557

Trimming the data to range 15 to 45 would probably be helpful in determining which equation fits best in this range.

ONE SAMPLE ANALYSIS

INTRODUCTION

DESCRIPTION

The one sample analysis program will accept complete or censored samples, sort, edit, or trim the data, and print descriptive statistics. Six theoretical cumulative distribution functions considered by the program are Normal, Log Normal, Logistic, Weibull, Exponential, and Uniform. The program will calculate and print the least squares estimates of the parameters for the distributions, and will plot their probability axes. Additionally, cumulative and relative frequency histograms may be drawn, as well as the empirical cumulative distribution function for the data against the six theoretical cumulative distribution functions.

Theoretical population percentiles, Kolmogorov-Smirnov and Cramer-VonMises goodness of fit tests, confidence intervals for the mean, and t-test of the sample mean may be calculated. Sample cumulative distribution functions may also be compared against theoretical cumulative distribution functions at each data point.

HARDWARE REQUIREMENTS

A Tektronix 4050-Series Graphic System with a minimum 16K memory is required for execution of this program.

If the Data Communications Interface (Option 1) is installed, minimum acceptable memory configuration is 24K bytes.

TAPE STRUCTURE

Tape file 45 on the program tape contains overlay instructions required for program execution. When the program tape has been replaced by another tape, necessary reinsertion of the program tape will be indicated by the alarm bell and a displayed message.

Magnetic tape file assignments for this program are specified in the table below:

FILE NUMBER	CONTENT OF THE FILE
45	User definable key and program overlay operating system
45	Data entry, data display, data plot, simple statistics, t-test and confidence intervals, data sort, data onto tape, data from tape, add data, delete data, change data, censor data, and trim data routines
47	Data sort, histogram, cumulative histogram, and empirical CDF routines
48	Data sort, quantiles, percentiles, and distribution parameters
49	Data sort and probability plots

ONE SAMPLE ANALYSIS

INTRODUCTION

PROGRAM LIMITS

For sample sizes greater than 100, programming modification is required. The variable H2 establishes the dimension of the data file, and must be altered at two locations to accomodate larger sample sizes. The variable is defined on lines 1690 and 3920 of file 46, and increasing the dimension in these locations will allow larger samples to be entered.

Variable H3 is assigned a value of 33, and thus allows data storage on the internal tape. Modification of the value of this variable makes data storage possible on other devices. Variable H3 is located on lines 3800 and 3880 of the store and load data routines contained in file 46.

METHODS

Density functions for the distributions which may be fit using the probability plotting methods in this program are:

DISTRIBUTION	DENSITY
Uniform	$\frac{1}{B-A} \qquad A < B$
Exponential	$\frac{1}{B} \exp\left[-\frac{(X-A)}{B}\right]$
Normal	$\frac{1}{\sqrt{2\Pi\sigma^2}} \exp\left(-\frac{(x-u)^2}{2\sigma^2}\right)$
Lognormal	$\frac{1}{\sqrt{2\Pi\sigma^2}} \exp\left(-\frac{(\log X-\mu)^2}{2\sigma^2}\right) \quad X>0$
Weibull	$ABX^{B-1} \exp(-AX^B) \qquad X \geqslant 0$
Logistic	$\frac{B \exp[-(A+BX)]}{[1+EXP[-(A+BX)]]^2}$

INTRODUCTION

Data entered from the keyboard is stored in a one dimensional array in internal memory, and is stored to tape only if the STORE DATA key is pressed. Editing takes place in memory only, but edited data may be stored on tape with the STORE DATA key.

The LIST DATA and PLOT DATA keys initiate action based on the data in memory, whether or not the data has been sorted.

Probability plotting is accomplished with a probability axis which is constructed for each distribution selected. From the plot, parameters of the distribution are estimated, and a "best" fitting line is drawn. If the assumed distribution is correct, the plotted points will tend to fall in a straight line.

If the plotted line appears not to fit censored or trimmed data, then the assumed model is not correct even though the data appears roughly linear. From the best fitting line, estimates of population parameters are found. Using these estimates, percentiles of the various distributions may be obtained. The sample cumulative distribution function and the assumed population distribution function are then compared.

For a sample entered into memory, let r_1 and r_2 represent points censored on the left and right respectively. Points trimmed on the left and right are represented by r_3 and r_4. Let F(.) be the cumulative distribution function of the model. Let $V_i = F^{-1}(P_i)$ where

$$P_i = \frac{r + i - \frac{1}{2}}{N + r_1 + r_2} \quad ;$$

$i = r_3+1, \ldots, N-r_4$.

The following are plotted for the distributions:

DISTRIBUTION	PLOT
Uniform	(V_i, X_i)
Normal	(V_i, X_i)
Lognormal	$(V_i, \log(X_i))$
Logistic	$(X_i, \log(P_i/(1-P_i)))$
Weibull	$(\log X_i, \log(-\log(1-P_i)))$
Exponential	$(-\log(1-P_i), X_i)$

A "best" line is then fit to the data points.

ONE SAMPLE ANALYSIS

INTRODUCTION

CENSORED DATA

Censored data may be defined as a known number of observations with both known and unknown values. Censoring is a sample property, not a population characteristic, and may be exemplified by the following: An experimenter attempts to estimate the mean weight of a population. 100 persons are to be weighed as the sample, but the scale available can only weigh objects in the range 100 to 200 pounds. 81 of the sample persons weigh between the range limits; 7 weigh less than 100; and 12 weigh more than 200. The results constitute censored data with a left censor point = 100, and right censor point = 200. We may say that 7 observations are censored on the left, and 12 observations are censored on the right.

TRIMMING DATA

The trim data operation causes data points which have values outside the desired range to be eliminated from calculations and plotting. When the TRIM DATA key is pressed, the number of points to be ignored on the left (too small) and on the right (too large) must be specified.

If the data has been sorted, the trimmed values will be ignored during the calculation of statistics and the t-test. If the data has not been sorted, trimming the data will have no effect on statistics and t-test. The effect of trimmed data on probability plots and distribution parameters is to increase the number of censored data points.

REFERENCES

Chernoff, H., Lieberman, G. J., "Use of Normal Probability Paper", *Journal of the American Statistical Association,* Vol. 49, 1954.

Chernoff, H., Lieberman, G. J., "The Use of Generalized Probability Paper for Continuous Distribution", *Annals of Mathematical Statistics,* Vol. 27, 1956, pp. 806–818.

Hahn, G. J., Shapiro, S. S., *Statistical Models In Engineering*, New York: John Wiley and Sons Inc., 1967.

Sarhan, A. E., Greenberg, B. E., *Contributions To Order Statistics*, New York: John Wiley and Sons Inc., 1962.

VARIABLES

VARIABLE	USAGE
C	Scratch Array
C0	Scratch Array
C1	Scratch
C2	Scratch
C3	Scratch
C4	Scratch
C5	Scratch
C6	Scratch
C7	Scratch
C8	Scratch
C9	Scratch
C$	Scratch
D0	Scratch
D1	Scratch
D2	Scratch
D3	Scratch
D4	Scratch
D5	Scratch
D6	Scratch
D7	Scratch
D8	Scratch
D9	Scratch
D$	Scratch
D (N)	The array which stores the data sample of size N
F	Scratch Array
F0	Scratch
F1	Scratch
F2	Scratch
F3	Scratch
F4	Scratch
F5	Scratch
F6	Scratch
F7	Scratch
F8	Scratch
F9(x)	Stores trimmed or censored values Flag values (x) are: 1 = left censor; 2 = right censor; 3 = left trimmed; 4 = right trimmed; and 5 = data is sorted
H1	Indicates which file is to be appended into memory, and which routine of the file is to be executed

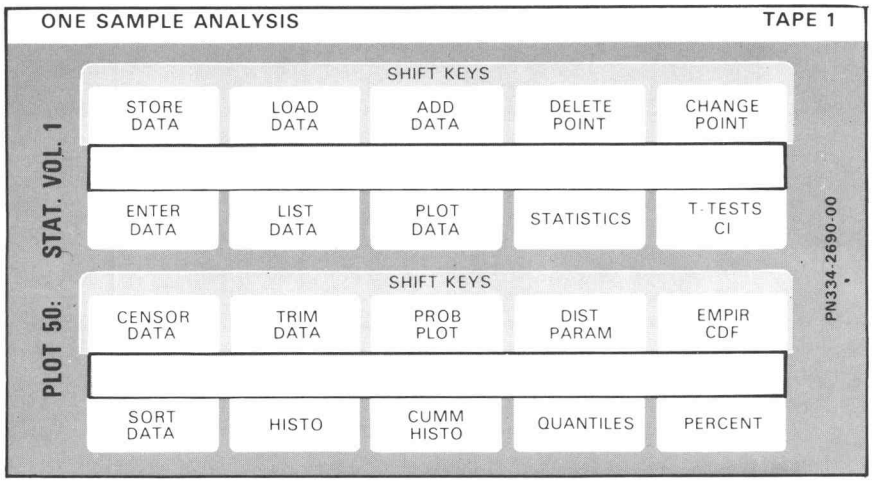
ONE SAMPLE ANALYSIS

VARIABLES

VARIABLE	USAGE
H2	Dimension of data array in the data entry routine and the data entry from tape routine
H3	Device address for data storage
H (x,y)	Stores parameters for distributions x values are: 1 = Normal; 2 = Log normal; 3 = Logistic; 4 = Weibull; 5 = Exponential; and 6 = Uniform. y values are: 0 = parameters undetermined; 1 = parameters stored in an array
N	Number of elements in the data sample

OPERATING INSTRUCTIONS

FUNCTION KEYS



KEY No.	KEY NAME	FUNCTION
1	ENTER DATA	allows entry of data from keyboard.
2	LIST DATA	prints entire data sample, including trimmed data.
3	PLOT DATA	plots data values.
4	SIMPLE STATISTICS	prints variable N, total, mean, median, variance, standard deviation, minimum, maximum, range, skewness, kurtosis, 3d moment, 4th moment, and the coefficient of variation for trimmed and censored sample.*
5	T–TESTS CI	calculates t-test of hypothetical mean; calculates confidence intervals for the mean for trimmed and censored sample.*
6	SORT DATA	sorts complete sample to ascending sequence in the same array in which it is stored.
7	HISTO	plots a histogram of the trimmed sample with a normal overlay if the normal parameters are calculated.*
8	CUMM HISTO	plots a cumulative histogram of the trimmed and censored data with a cumulative normal overlay if the normal parameters are calculated.*

* If the data has not been sorted, the complete sample is used.

ONE SAMPLE ANALYSIS

OPERATING INSTRUCTIONS

Key	Key Name	Function
9	QUANTILES	calculates the sample cumulative distribution function (CDF), the distribution CDF, and the difference between the two for each data value; prints the Kolmogorav-Smirnov and the Cramer-VonMises tests; prints the distribution parameters.
10	PERCENT	calculates theoretical deviate value for given cumulative probabilities.
11	STORE DATA	stores complete data sample to tape.
12	LOAD DATA	allows entry of data from tape.
13	ADD DATA	adds data to data previously entered.
14	DELETE POINT	removes incorrect value from sample.
15	CHANGE POINT	allows correction of data value.
16	CENSOR DATA	provides for the entry of the number of unknown values in the sample.
17	TRIM DATA	excludes out of range data values from calculations.
18	PROB PLOT	plots the trimmed and censored sample for selected distributions.
19	DIST PARAM	displays the distribution parameters of the trimmed and censored data.
20	EMPIR CDF	plots the empirical cumulative distribution function versus theoretical distribution.

PROGRAM LOADING

This program may be loaded automatically from the directory, or manually from the keyboard.

AUTOMATIC LOADING FROM THE DIRECTORY

1. Insert the program tape.
2. Press AUTO LOAD. The program directory will be displayed with the message ENTER THE PROGRAM NUMBER YOU WANT.
3. Enter 27; press RETURN.
4. When the I/O light goes out, execute the program.

MANUAL LOADING FROM THE KEYBOARD

1. Insert the program tape.
2. Enter FIND 45; press RETURN.
3. Enter OLD; press RETURN.
4. When the I/O light goes out, execute the program.

PROGRAM EXECUTION

One Sample Analysis data entry and program execution are described in the comprehensive example which follows.

ONE SAMPLE ANALYSIS

EXAMPLES

Measurements of a contaminant, expressed as a percentage, have been taken from a chemical compound. The measurements have been tabulated below.

OBSERVATION NUMBER	CONTAMINANT PER CENT
1	.0503
2	.0231
3	.0689
4	.0250
5	.0120
6	.0968
7	.0305
8	.0128
9	.0363
10	.0139
11	.0402
12	.0171

During 4 other attempts, contaminant was present but in an amount too small to be measured.

What is the likelihood of various amounts of contaminant appearing in future batches of the compound?

Press ENTER DATA (key No. 1), to establish the data sample.

```
                One Sample Analysis Data Entry

Enter data values, one by one
.0503
.0231
.0100
.0689
.0250
.0120
.0968
.0350
.0128
.0139
.0402
.0171
```

When the 12th observation has been entered, press LIST DATA (key No. 2) to verify accuracy of the entries.

EXAMPLES

```
One Sample Analysis Data


0.0503
0.0231
0.01
0.0689
0.025
0.012
0.0968
0.035
0.0128
0.0139
0.0402
0.0171
```

In this example, the list reveals the following errors: entry number 3 is entirely incorrect and should be deleted; entry number 8 was entered as .035 and must be changed to .0305; and observation number 9 (.0363) was omitted and must be added.

DELETE POINT (key No. 14) will delete the entered value when RETURN is pressed.

```
Delete Data

Enter data values to be deleted, one by one
.01
```

To change .035 to .0305, press CHANGE DATA (key No. 15), enter the old and new values values as shown, and press RETURN.

```
Change Data

Enter the value to be deleted
and the new value to be inserted

old value, new value .0350,.0305

old value, new value
```

ADD DATA (key No. 13) will enable addition of the omitted data.

```
Add Data

Enter additional data values, one by one
.0363
```

EXAMPLES

Again, the LIST DATA (key No. 2) is pressed to list the entries which are now correct.

```
                    One Sample Analysis Data


0.0503
0.0231
0.0689
0.025
0.012
0.0968
0.0305
0.0128
0.0139
0.0402
0.0171
0.0363
```

Press CENSOR DATA (key No. 16), establish the 4 unknown observations at the low end of the data sample, and press RETURN.

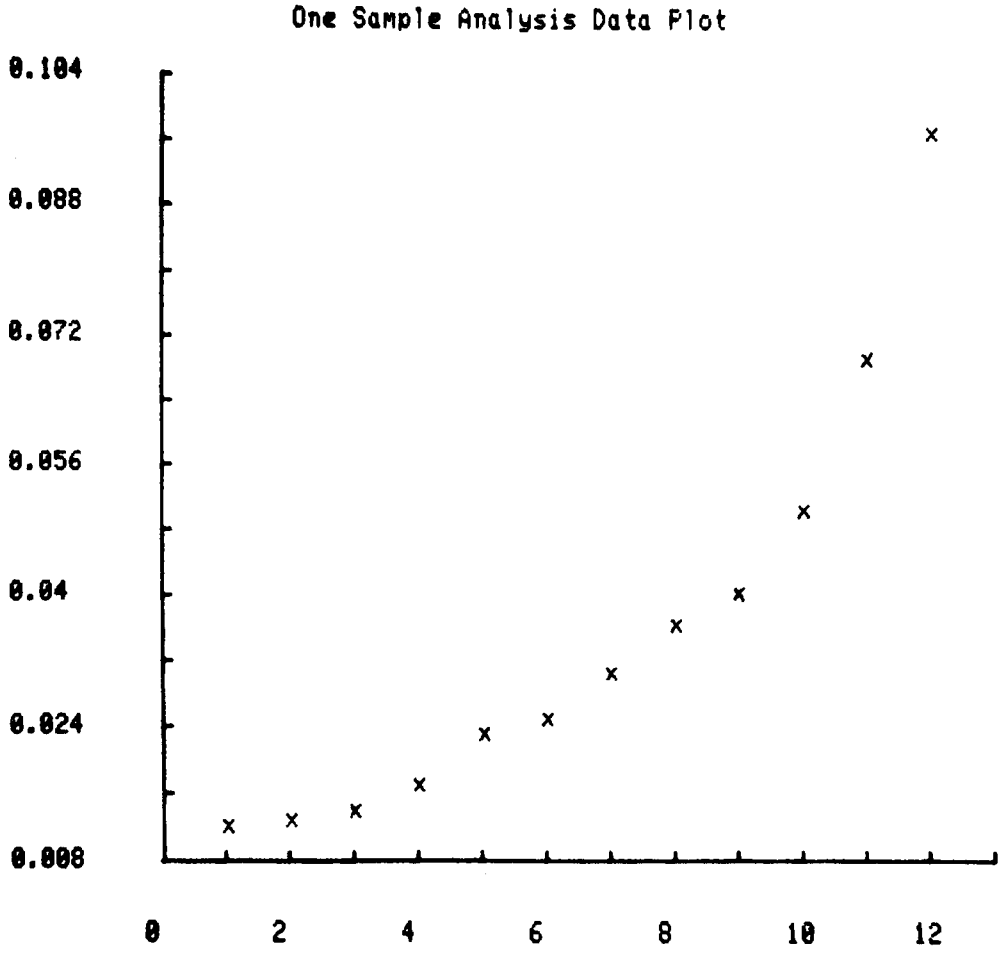
```
                         Censor Data

 Left censored=0
Right censored=0

enter new values 4,0
censored routine complete
```

SORT DATA (key No. 6) will cause the sample to be sorted to ascending sequence. A displayed message acknowledges completion of the sort.

```
Sort Data
Data sort complete
```

EXAMPLES

PLOT DATA (key No. 3) will graphically display the data values.

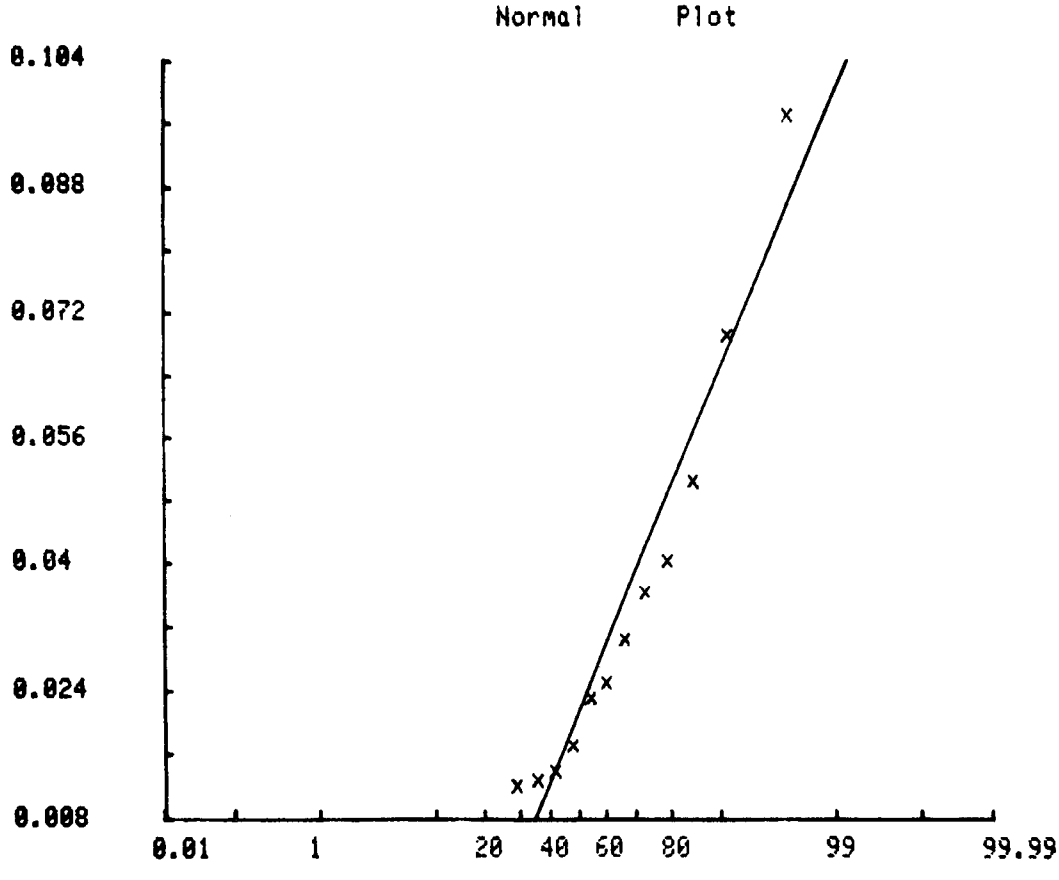


Probability plots will determine the distribution which best describes the data sample. PROBABILITY PLOTS (key No. 18) offers a choice of plots as shown on the displayed menu.

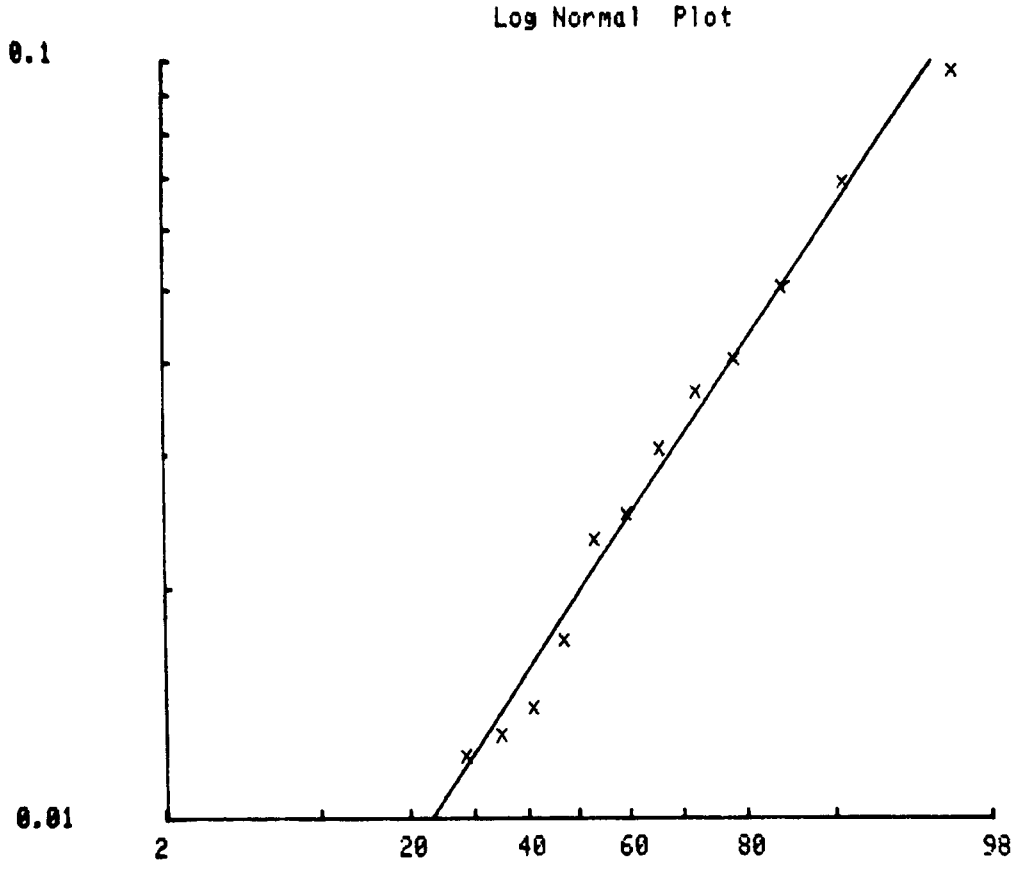
```
                    Probability Plots

Enter

 1 - Normal Plot
 2 - Log Normal
 3 - Logistic
 4 - Weibull
 5 - Exponential
 6 - Uniform
```

To illustrate this example, all 6 options are selected.

EXAMPLES

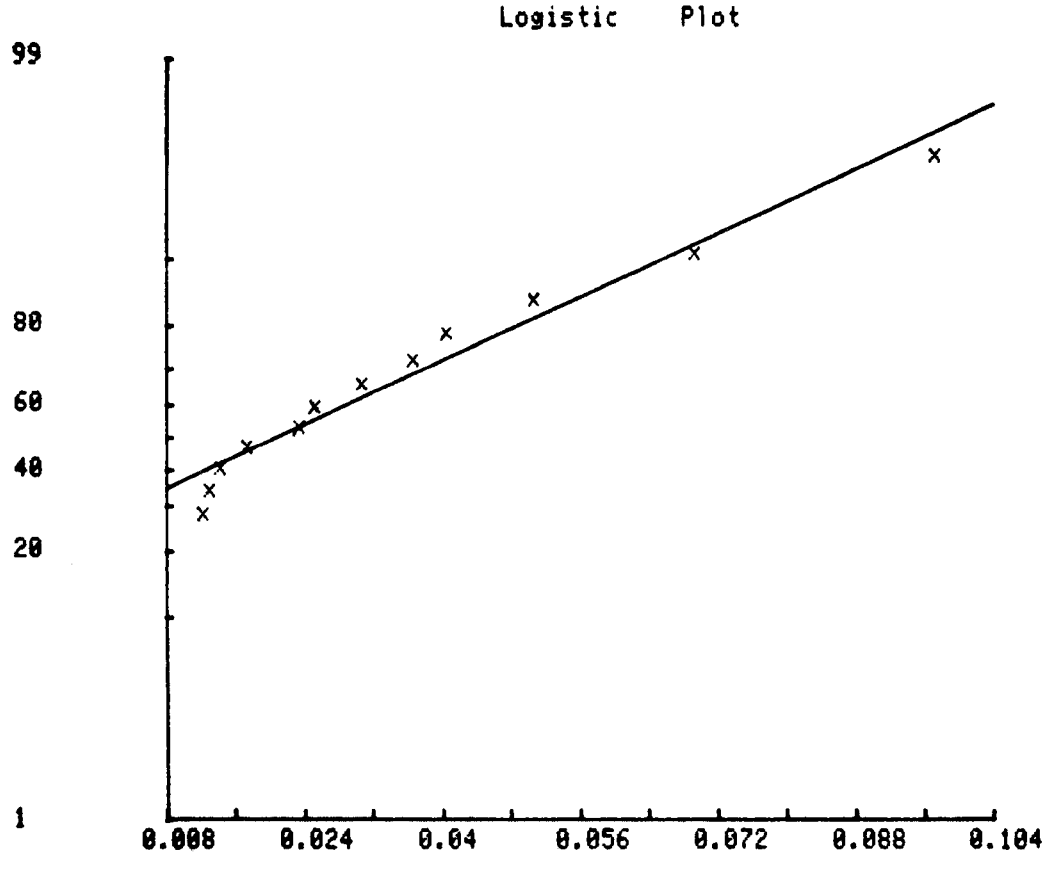


Censored: Lt= 4 Rt= 0 Trimmed: Lt= 0 Rt= 0

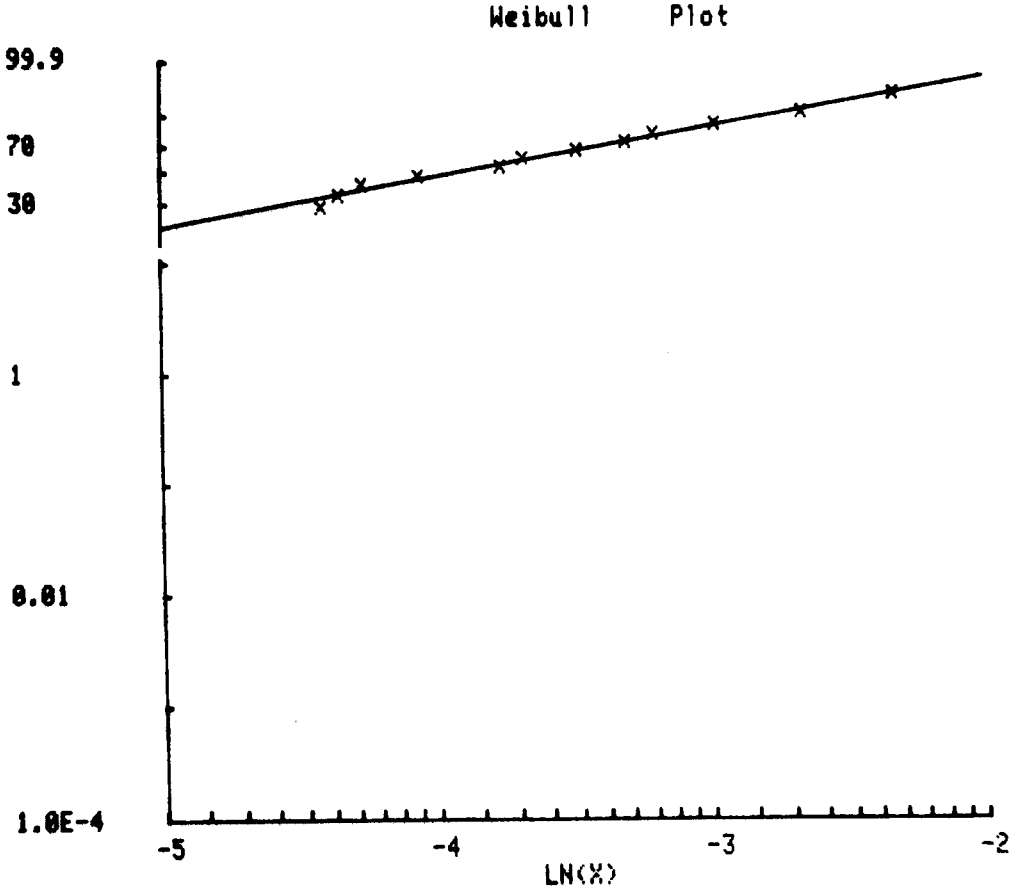


Censored: Lt= 4 Rt= 0 Trimmed: Lt= 0 Rt= 0

EXAMPLES

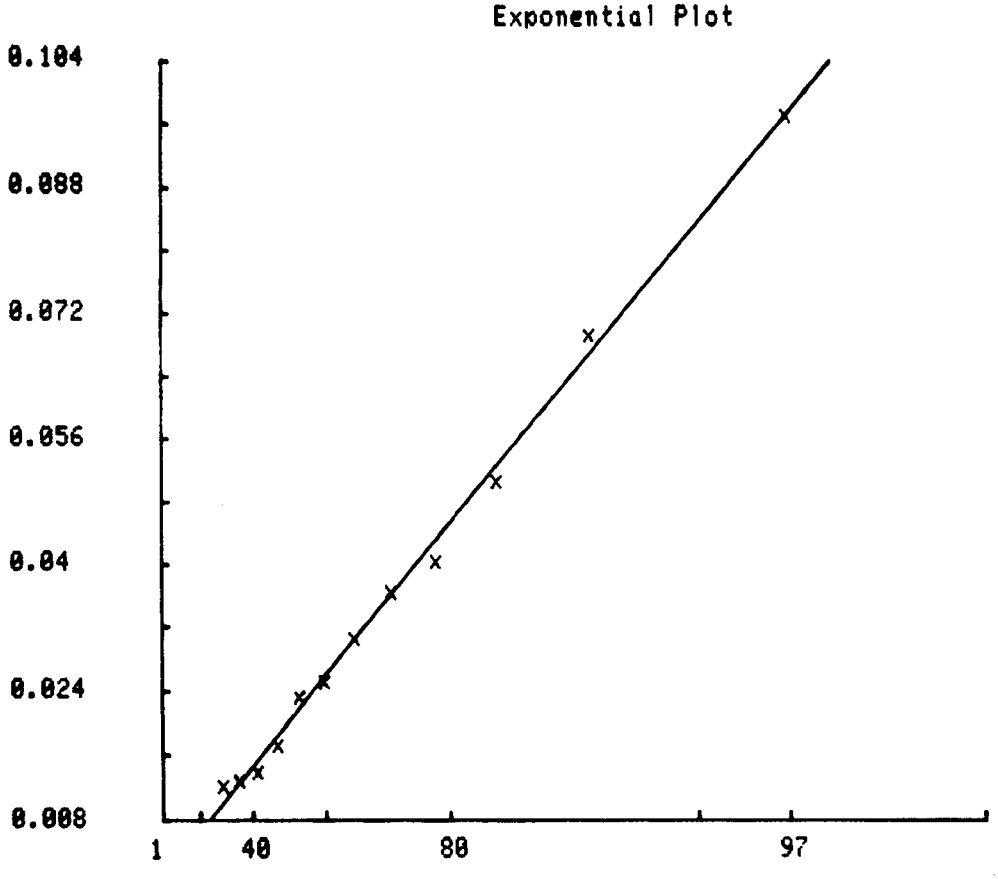


Censored: Lt= 4 Rt= 0 Trimmed: Lt= 0 Rt= 0

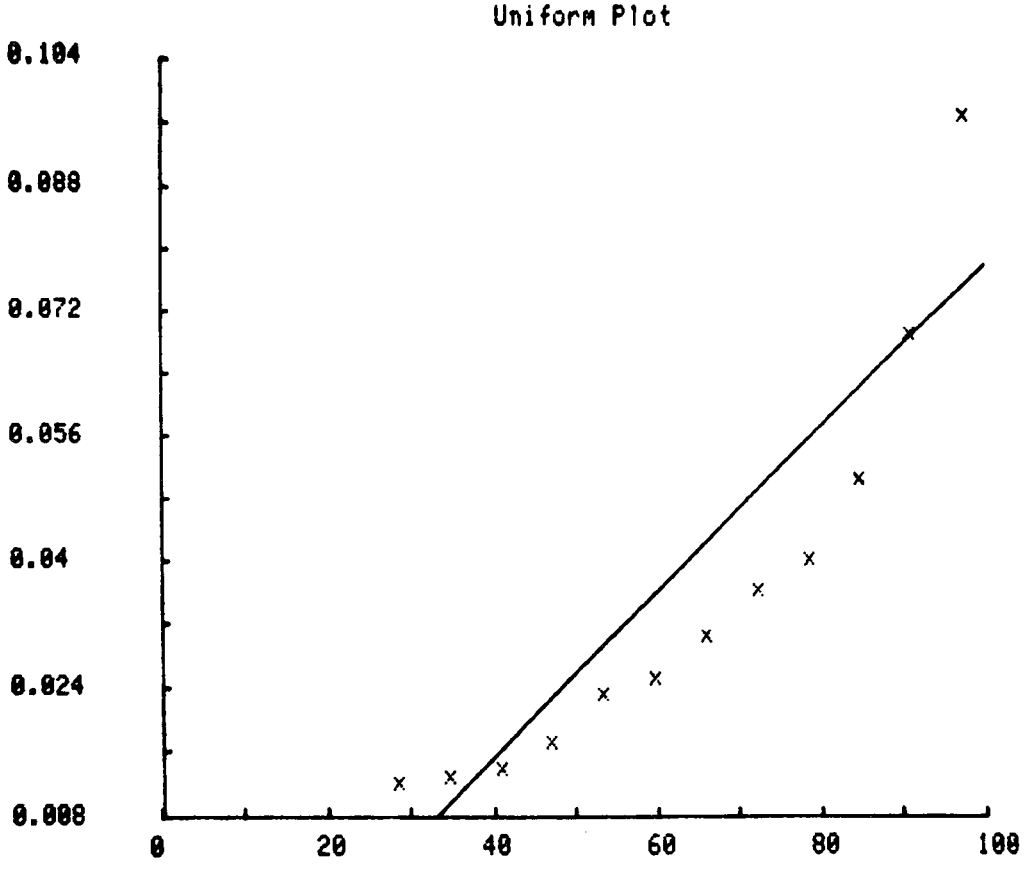


Censored: Lt= 4 Rt= 0 **Trimmed:** Lt= 0 Rt= 0

EXAMPLES



Censored: Lt= 4 Rt= 0 Trimmed: Lt= 0 Rt= 0



The data is best fitted by the Weibull and Exponential plots, and the remainder of the analysis may be limited to those options.

DISTRIBUTION PARAMETERS (key No. 19) will display the parameters used in plotting.

Distribution Parameters

Distribution	A	B
Normal	0.0214757248086	0.0340620208205
Log Normal	-1.70646725023	0.397744102007
Logistic	-1.01754245687	48.8932884929
Weibull	41.7346112	1.05146163663
Exponential	6.831854631E-4	0.0277119266234
Uniform	-0.0265454545455	0.104505090909

Censored: Lt= 4 Rt= 0 Trimmed: Lt= 0 Rt= 0

EXAMPLES

For the normal distribution A is the mean and B is the standard deviation. For the log normal A is the mean and B is the standard deviation of the logarithm of the data.

The QUANTILES key (key No. 9) will cause a menu to be displayed, and the Weibull and Exponential options are selected.

```
                              Quantiles

                    Enter

                     1 - Normal Distribution
                     2 - Log Normal
                     3 - Logistic
                     4 - Weibull
                     5 - Exponential
                     6 - Uniform
```

```
                          Quantiles

Data            Sample CDF        Weibull           Difference

 0.012           0.28125          0.328920688569    -0.0476706885691
 0.0128          0.34375          0.347454594705    -0.00370459470531
 0.0139          0.40625          0.372197719097    0.0340522809029
 0.0171          0.46875          0.439452548055    0.0292974519452
 0.0231          0.53125          0.548030299864    -0.0167802998644
 0.025           0.59375          0.578089535749    0.0156604642511
 0.0305          0.65625          0.654803959385    0.001446040615
 0.0363          0.71875          0.721211413181    -0.00246141318088
 0.0402          0.78125          0.758764202284    0.0224857977156
 0.0503          0.84375          0.834682212889    0.00906778711138
 0.0689          0.90625          0.918381263267    -0.0121312632665
 0.0968          0.96875          0.972193219575    -0.00344321957518

          Kolmogorov-Smirnov Test  =0.0476706885691
          Cramer-Von Mises Test    =0.0125303989041
          A                        =41.7346112
          B                        =1.05146163663

Censored: Lt=   4   Rt=   0     Trimmed: Lt=   0   Rt=   0
```

Quantiles

Data	Sample CDF	Exponential	Difference
0.012	0.28125	0.335269398116	-0.0540193981156
0.0128	0.34375	0.354184788913	-0.0104347889135
0.0139	0.40625	0.379317728175	0.0269322718252
0.0171	0.46875	0.447006877595	0.0217431224055
0.0231	0.53125	0.554662558996	-0.0234125589962
0.025	0.59375	0.584172815532	0.00957718446763
0.0305	0.65625	0.659028379467	-0.00277837946733
0.0363	0.71875	0.72341917763	-0.00466917762968
0.0402	0.78125	0.759728519117	0.021521480883
0.0503	0.84375	0.833114918492	0.0106350815079
0.0689	0.90625	0.914705132115	-0.00845513211456
0.0968	0.96875	0.968834006242	-8.400624157E-5

Kolmogorov-Smirnov Test =0.0540193981156
Cramer-Von Mises Test =0.012486701682
A =0.000683185463094
B =0.0277119266234

Censored: Lt= 4 Rt= 0 Trimmed: Lt= 0 Rt= 0

When the PERCENTILES (key No. 10) is pressed, we again elect the Weibull and Exponential distributions from the selection offered.

Percentiles

Enter

1 - Normal Distribution
2 - Log Normal
3 - Logistic
4 - Weibull
5 - Exponential
6 - Uniform

EXAMPLES

Population Percentiles

%	Weibull
0.1	0.0000403506901004
1.0	0.000362055592372
2.0	0.000703336789985
2.5	0.000871731312916
5.0	0.00170611986906
10.0	0.0033831902571 4
50.0	0.0202969806377
90.0	0.0635774768018
95.0	0.0816576804394
97.5	0.0995324007248
98.0	0.105250224579
99.0	0.122913613642
99.9	0.180747716812

A=41.7346112
B=1.05146163663

Censored: Lt= 4 Rt= 0 Trimmed: Lt= 0 Rt= 0

Population Percentiles

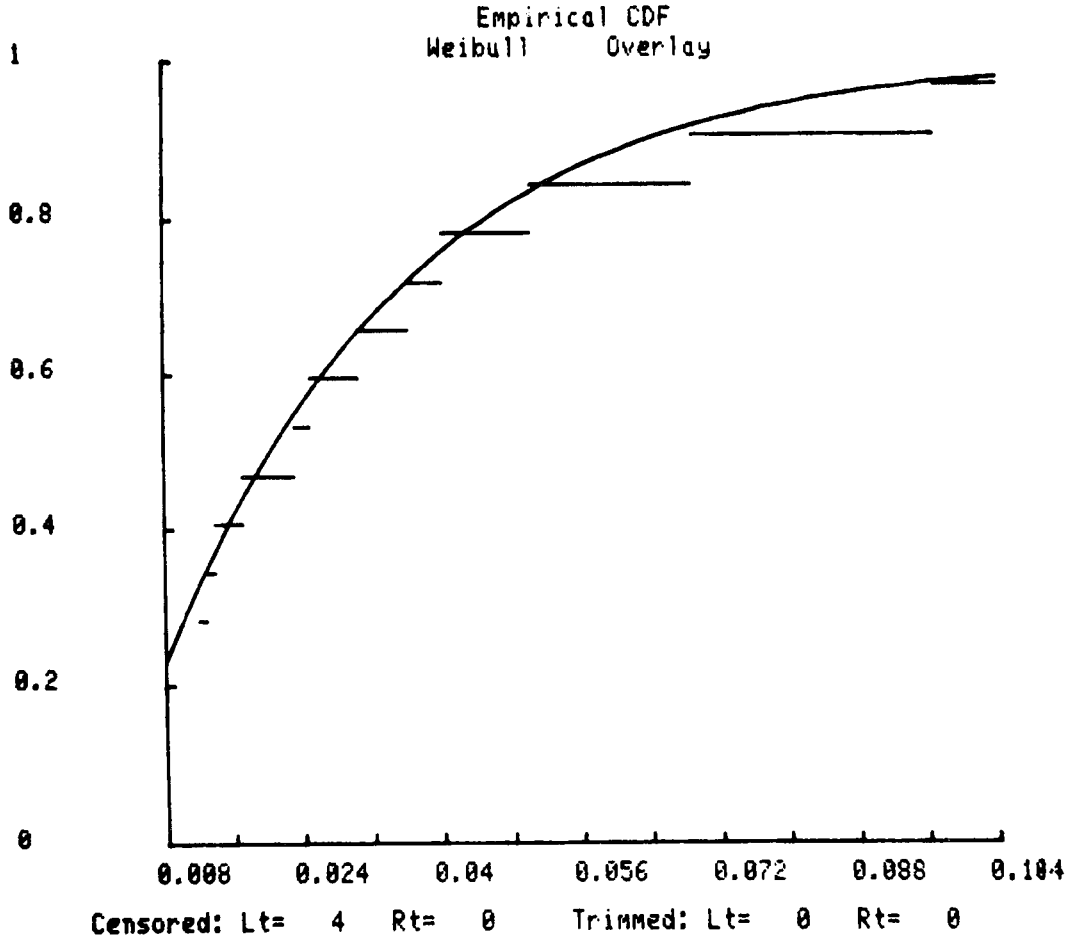
%	Exponential
0.1	0.000710911254924
1.0	0.000961699632806
2.0	0.00124304140587
2.5	0.00138479070022
5.0	0.00210462147343
10.0	0.00360292834201
50.0	0.01989162927
90.0	0.0644922546043
95.0	0.0837006984112
97.5	0.102909142218
98.0	0.109092879939
99.0	0.128301323745
99.9	0.192110392886

A=0.000683185463094
B=0.0277119266234

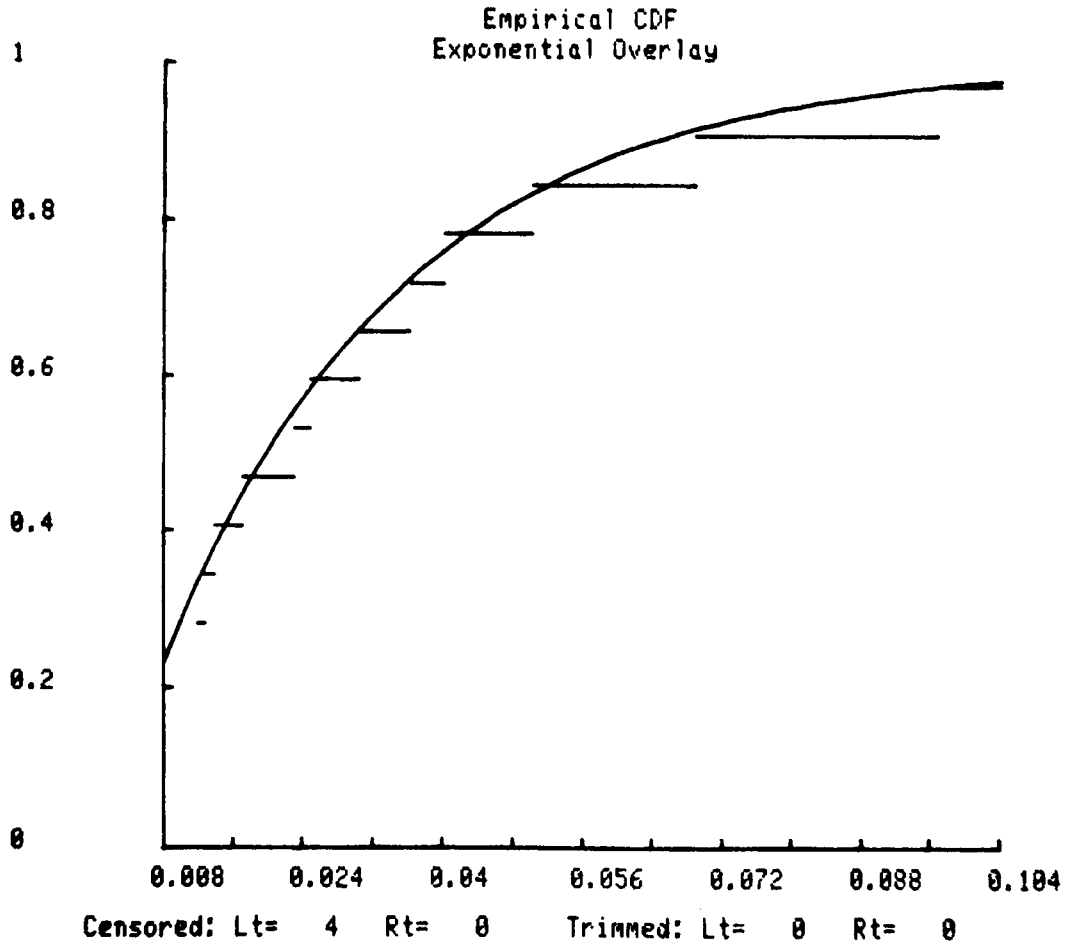
Censored: Lt= 4 Rt= 0 Trimmed: Lt= 0 Rt= 0

EMPIRICAL CDF (key No. 20) provides option choices from the display shown here.

```
                    Empirical CDF

Enter

 1 - CDF with Normal Overlay
 2 - Log Normal
 3 - Logistic
 4 - Weibull
 5 - Exponential
 6 - Uniform
 7 - CDF w/o Overlay
```



EXAMPLES



Press SIMPLE STATISTICS (key No. 4) for the following display:

Simple Statistics

N	=12.
Total	=0.4269
Mean	=0.035575
Median	=0.02775
Variance	=0.000661511136364
Std Dev	=0.0257198587936
Min	=0.012
Max	=0.0968
Range	=0.0848
Skewness	=1.25647952264
Kurtosis	=3.69061731859
3rd Moment	=0.0000187619646563
4th Moment	=0.00000135705113698
Coeff of Var	=0.722975651261

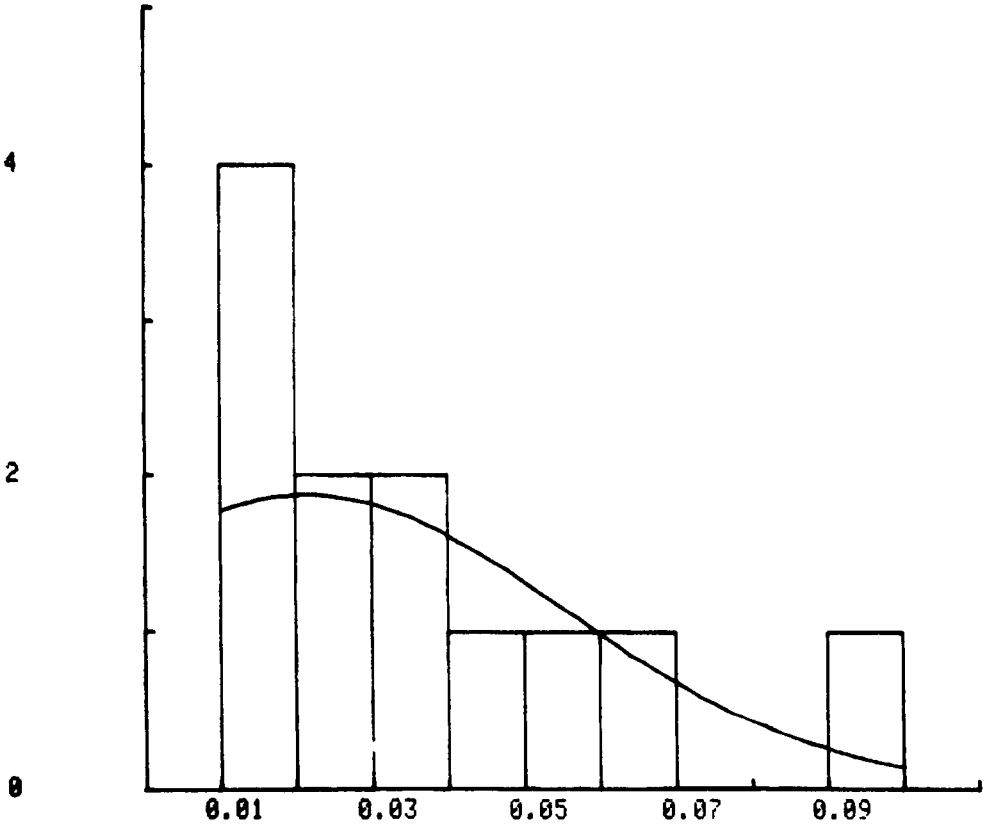
Censored: Lt= 4 Rt= 0 Trimmed: Lt= 0 Rt= 0

EXAMPLES

A menu is displayed when HISTO (key No. 7) is pressed, and information is entered as shown in the example. The histogram is displayed when RETURN is pressed at the completion of the entries.

```
                    Histogram


                      Min=0.012
                      Max=0.0968
                    Range=0.0848

Enter
 1 to specify # of cells
 2 to specify cell width
 3 to specify offset and cell width
3

Enter offset and cell width .01,.01
```

Histogram

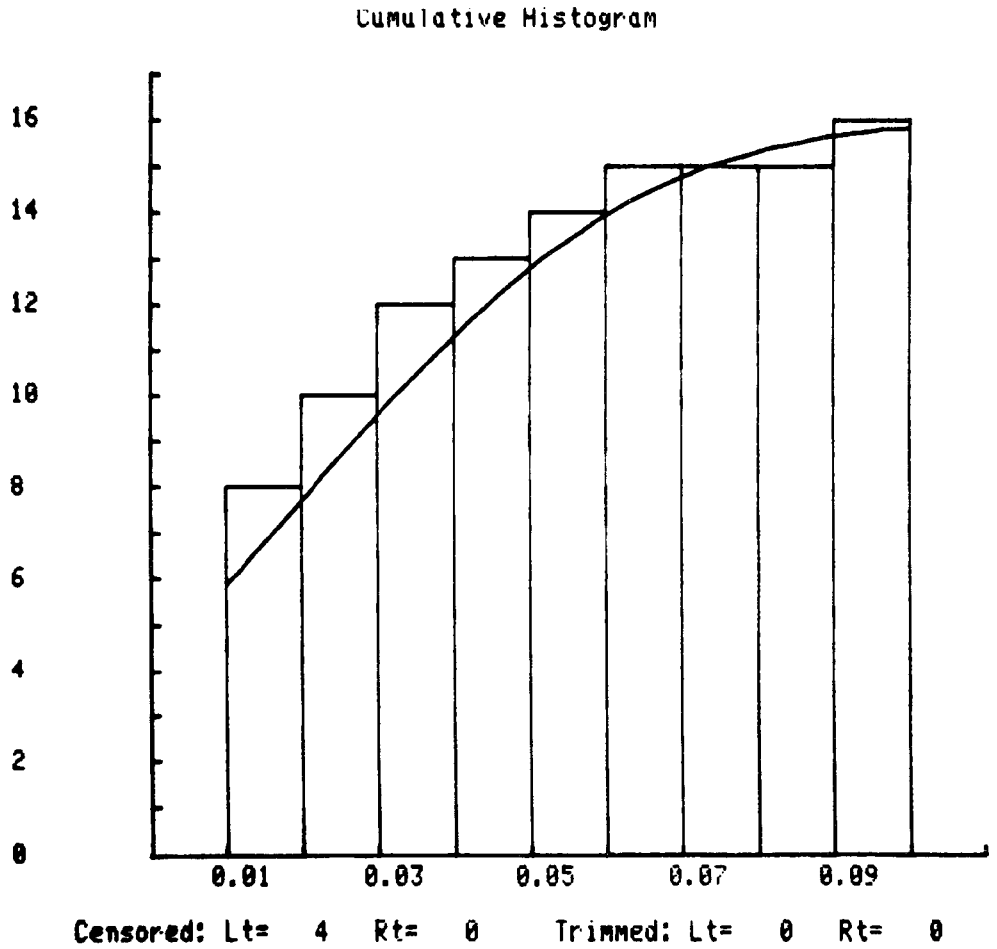


Censored: Lt= 4 Rt= 0 **Trimmed:** Lt= 0 Rt= 0

EXAMPLES

CUMM HISTO (key No. 8) is used in the same manner.

```
                    Cumulative Histogram

                      Min=0.012
                      Max=0.0968
                    Range=0.0848

Enter
 1 to specify # of cells
 2 to specify cell width
 3 to specify offset and cell width
3

Enter offset and cell width .01,.01
```



EXAMPLES

t-Test calculation is initiated by pressing T-TEST (key No. 5). In addition to the traditional confidence intervals of 90, 95, and 99, other confidence intervals may be specified.

```
                    T-Test & Confidence Intervals

Enter hypothesized mean .04

Do you wish any other confidence
intervals besides 90, 95, & 99 (Y or N) Y
How many addl conf. levels 1
Enter conf. levels
99.9


          Hypothesized mean  =0.04
          T-Test             =-0.595984984598
          DF                 =11.
          Std error          =0.00742468369901


Conf. Level    Lower Limit          Upper Limit

   90.0       0.0222411345474      0.0489088654526
   95.0       0.0192334296767      0.0519165703233
   99.0       0.0125157619196      0.0586342380804
   99.9       0.00263567686797     0.0685143231321
```

To store the data sample to tape on a previously marked data file, press STORE DATA (key No. 11). The message displayed on the screen will prompt removal of the program tape, and request the data file number.

```
To Tape

Insert data tape and enter the tape file number 6
```

Remove the program tape; insert the correct data tape; enter the file number of the data file. In this example, data file number 6 was used.

When the data has been stored to the tape file, the completion message shown below will be displayed.

```
Re-insert program tape.

To tape complete
```

EXAMPLES

To continue program execution, re-insert the STATISTICS, VOLUME 1 program tape.

To retrieve this data sample later, press LOAD DATA (key No. 12). The message shown below prompts removal of the program tape and requires the entry of the data file number.

```
One Sample Analysis Data Entry From Tape

Insert data tape and enter the tape file number
```

When the data tape has been inserted, enter the file number and press RETURN.

After all data has been entered, the following message will appear.

```
RE-INSERT PROGRAM TAPE.
FROM TAPE COMPLETE.
```

When the program tape has been re-inserted, analysis may begin.

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SOFTWARE CHANGE INFORMATION

PRODUCT PLOT 50
STATISTICS VOLUME 1

CHANGE REFERENCE M32093
DATE 10-27-77

CHANGE:	DESCRIPTION

EFF SN B060558

062-1854-00

REASON FOR CHANGE:

1. 8K byte machine is unable to enter data. 16K byte machine gets a MEM FULL during calculations.
2. The regression routine does not correctly trap negative or zero x and y values.

DESCRIPTION OF CHANGE:

1. Delete line 488 in File 36. Delete lines 640, 960, 1630, and 1720 from File 40. Change line 110 in File 40 to read WO=95+205*(MEMORY>8000).
2. The following changes correct the problem:
   a. Change line 1240 in File 42 to read

      IF B2+B3<0 THEN 1270

   b. Add line 505 to File 43 which reads

      IF B2+B3<0 THEN 710

   c. Add line 1145 to File 43 which reads

      IF B2+B3<0 THEN 1210

   d. Change line 1110 in File 44 to read

      IF B2+B3<0 THEN 1140

   e. Add line 2305 to File 44 which reads

      IF B2+B3<0 THEN 2460

   f. Add line 2895 to File 44 which reads

      IF B2+B3<0 THEN 2960